Physics and Poetry

Exploring Physics Through the Medium of Poetry

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SUMMARY

This thesis is in two parts: Part 1 is a collection of 39 poems which use a range of visual and digital techniques to explore, express and explain key concepts in contemporary physics. The poems are presented in three major sections, devoted (respectively) to themes of light, probability & uncertainty, and university. Part 2 is the commentary, comprising four chapters: the first is a strategic overview of the relationship between poetry and science, focusing on major indicative instances and moments, concerning Lucretius, Pope, Blake, Keats, MacDiarmid, and Morgan, and then moving on to consider a series of explorations of how physical principles bear striking similarities to the mechanics of digital poetics. The remaining three chapters address in turn the scientific issues which form the subject matter of each of the three sections of poetry, as well as providing poem-specific commentary and procedural analysis for each one, arranged as follows: Chapter 2 discusses poems 1-13 inclusive, Chapter 3 poems 14-28 inclusive, and Chapter 4 poems 29-39 inclusive. Within each of these chapters, further thematic sub-divisions of the three major themes are employed, as indicated in the list of contents. In the procedures, imagery, metaphors, and motifs they employ, the poems draw upon and develop some of those used in a range of prose works written by scientists and science writers to explain and elucidate the complex theories and concepts of contemporary physics to a lay audience. The poems are intended to work cumulatively in combination with each other, and also in juxtaposition with the poem-specific commentaries and the broader explicatory parts of the commentary to explore the scientific concepts and familiarise readers with them.

Physics and Poetry

Contents

Introduction

The relationship between science and poetry is itself a complex and dynamic system, fluctuating sporadically between alliance and enmity. On the surface this seems to be the result of a single conflict between two stereotypical worldviews, often portrayed as fundamentally incompatible, those being a) the creative and imaginative poet seeking to transcribe the beauty of the world, endlessly and open-mindedly experiencing its myriad possibilities, and b) the scientist who reduces the world to a set of dull and lifeless rules and equations, who, as Charles Lamb said of Isaac Newton, believe 'nothing unless it was as clear as the three sides of a triangle.'[1]

The aim of this thesis is to explore the ways in which concepts and theories from physics can be expressed through the medium of poetry, using a broad range of styles, media, and visual forms. Unlike many other examples of what has been described as 'science poetry', this thesis does not seek to appropriate ideas and terminology from physics to be applied to other unrelated poetic subjects. This thesis sets physical theories as its subject, producing poems that both express and embody those theories, keeping them as scientifically accurate as possible. Each of the thirty-nine poems focuses on a single concept, arranged in a sequence of logical progression from 19th century revelations of physicists such as Michael Faraday and James Clerk Maxwell concerning the mechanics of light, through Albert Einstein's work on relativity in the early years of the 20th century, into the revolutionary discoveries of quantum mechanics, expanding into astrophysics and our understanding of the beginning of the

[1] Alfred Ainger, *Charles Lamb* (New York: Cambridge University Press, 2011), p86.

universe, concluding with the theoretical predictions of contemporary physics in areas such as string theory and M-theory. In doing so, the thesis makes use of a select range of non-technical science writing from physicists such as Brian Greene, Michio Kaku, Neil DeGrasse Tyson, Stephen Hawking, Brian Cox, Jeff Forshaw, Richard Feynman, and even Albert Einstein himself, as well as professional science writers such as Marcus Chown, John Gribbin, and Graeme Farmelo. The use of these sources as both the creative basis for the poems themselves, and as a means of explaining the physics of each piece in the commentary, ensures that the accuracy of the science is kept as intact as possible in both poetry and discussion.

The thesis itself is divided into two parts: the first contains all thirty-nine poems, and the second – the commentary – consists of four chapters. The first chapter is split into two sections, the first half of which explores the complex relationship between science and poetry over the centuries. Beginning the work of the Latin poet Lucretius (who praised the sciences' emphasis on rationality, reason, experimentation, and evidence in seeking an understanding of the universe), moving through the effects of lingering religious dogmatism on science through the Enlightenment, on to the Romantic poets' objections to the attitudes of scientists of their day, concluding with the work of Hugh MacDiarmid, who called on poets to unite their work and their methods with the discoveries of the sciences. The second section discusses a selection of digital poetry – a medium used among the poems of this thesis – and how digital poetry itself contains an inherent reflection of contemporary physics in its design.

The second chapter discusses the first thirteen poems in the thesis. Beginning with explorations of the mechanics of light, this chapter starts with

the 19th century view of light as a wave, moving on to reasons for the finitude of the speed of light, the subsequent rise of relativity as a result as well as the implications of relativity, before introducing the problems with the wave view of light and its apparent disproval by Einstein, concluding with the complications that arose in reconciling those experiments that had confirmed the view of light as a wave, and those that confirmed it to be a particle.

The third chapter expands on this by moving into the subatomic world, discussing the next group of fifteen poems. These introduce, first of all an understanding of the size and structure of an atom, going on to describe the four fundamental forces that govern all interactions in the universe. From this, the poems explore the end of the either/or opposition of the wave/particle view of light in favor of a dualistic view of fundamental particles that emerged during the formative years of quantum mechanics. The poems that follow this focus on how we may conceive of something that exists as both wave *and* particle, and many of the strange features that were revealed by quantum mechanics, such as the uncertainty principle, the effect of observation on the states of particles, and the rise of probability over deterministic views of physics.

Taking the discussions of the previous two chapters, the final chapter, in exploring the final group of eleven poems, extends their theoretical concerns out into the universe itself, moving into astrophysics. This section begins with a description of our understanding of the birth and formative moments of the universe, including the emergence of the four forces, and our detection of the leftover heat from this 'big bang'. The poems then move on to discuss how stars are formed (and how these stars produce the elements of the periodic table), how black holes are formed in the deaths of massive stars, the strange forms of

matter and energy that are, respectively, holding the universe together and causing it expand apart at an accelerating rate, and the universal field that is responsible for the varying masses/charges of all fundamental particles. The piece concludes with brief explorations of string theory and M-theory, which are mathematical models that unify relativity and quantum mechanics as a single theory, but remain experimentally unconfirmed.

The poems themselves, throughout the collection, make use of unique visual forms, constructed specifically around the individual subject on which they focus, the function and methodology of which is discussed in the commentary. These specific forms vary greatly, but all share the sole purpose of best exemplifying their respective subjects through poetry as a written medium, making use of the space of the page/screen as another means of conveying meaning, working in unison with the language of each piece. This enables each poem to discuss, describe, and demonstrate physical theories and idea, that, while being poetry, are also explicitly scientific, demonstrating how, in the unification of science and poetry, the science need not be 'assimilated' by the poetry, instead advocating an integration of both with each other into a single form; rather than writing poems *about* science', or poems that *use* scientific terminology, these pieces are science *written as* poetry.

Part One: Poems

1. Of Light

1. Let There Be…

In the Beginning there was
[redacted]
and the Universe said . . .

"Let there be...
∇*h, I don't know*
.
*Som****E****thing****.***
*Sum****=****thing*
*to s****ρ****read, to wrap*
around my **/**ife; my spaces, my times;
an ***ε****nergy, a force, a whole to dance between me,*
to ***0****scillate and flux.*

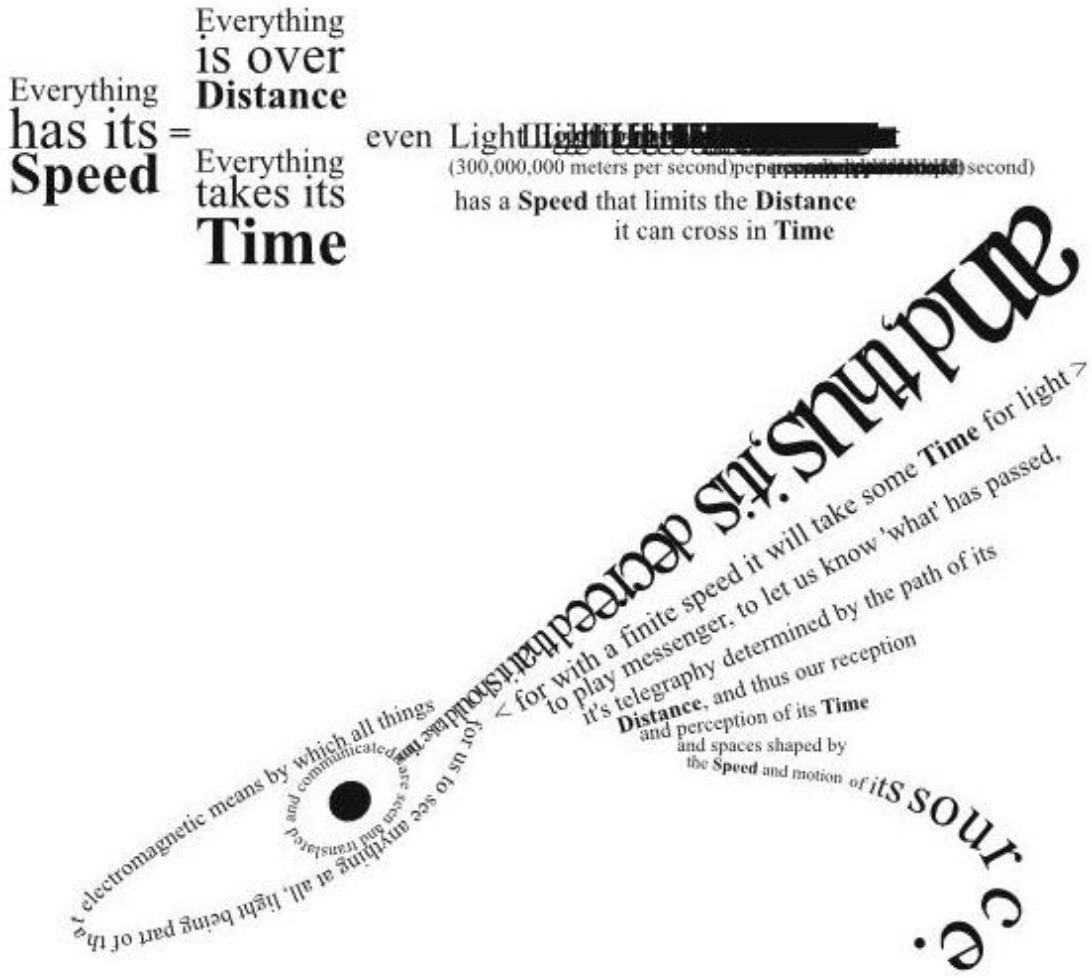
∇*ne thing is clear*
.
It must ***B****e*
=*, a field balanced, from end to end.*

∇*therwise I would look silly,*
*to e****x****ist*
*all lopsid****E****d. And I must see*
*my****=****self*
- *so naturally*
∂
B*right affair, both common and regal,*
*fabu****/****ous,*
*d****∂****ring, attainable by all and sundry;*
a **t***rue sight.*

*S****∇****mething to invoke it,*
*an e****x****pression to declare that it*
is there… A ***B****old calling card*
that is its **=** *in weight and wonder,*
*synonymo****μ****s with its presence and life.*
*C****0****uld that be it? No, but something*
J*ust like it, that perfectly docks,*
like a twin; 'life' **+** *...*
'Yo***μ***' *and 'Me',*
*and s****0****mething*
ε*lse . . .*
*A c****0****mbination,*
a hybri***∂*** *- 'it is'/'it brings',*
*'Life'/'****B****right' . . .*
/*a, le, lo, lu . . .*
*Foun****∂****! At last! Eureka*
*I say; let there be' Ligh****t****!'"*

2. Racing Light

3. The Speed of Light



4. Energy and Mass

The Energy contained within an object

is equal to its

Mass multiplied by

C, or the speed of light,

squared

$$E = MC^2$$

∴ (which means 'therefore')

to travel faster mass requires more energy which bloats and bloats its mass which requires more energy which bloats and bloats its mass

which requires more energy which bloats and bloats its mass which requires more energy which bloats and bloats its mass

which requires more energy which bloats and bloats its mass which requires more energy

which bloats and bloats its mass which requires more energy

which bloats and bloats its mass which

until at *c*. M = ∞ and ∞E is required

You cannot pass, says light.

5. You Relative to Me (Time)

Please refer to the included CD-ROM to access this piece

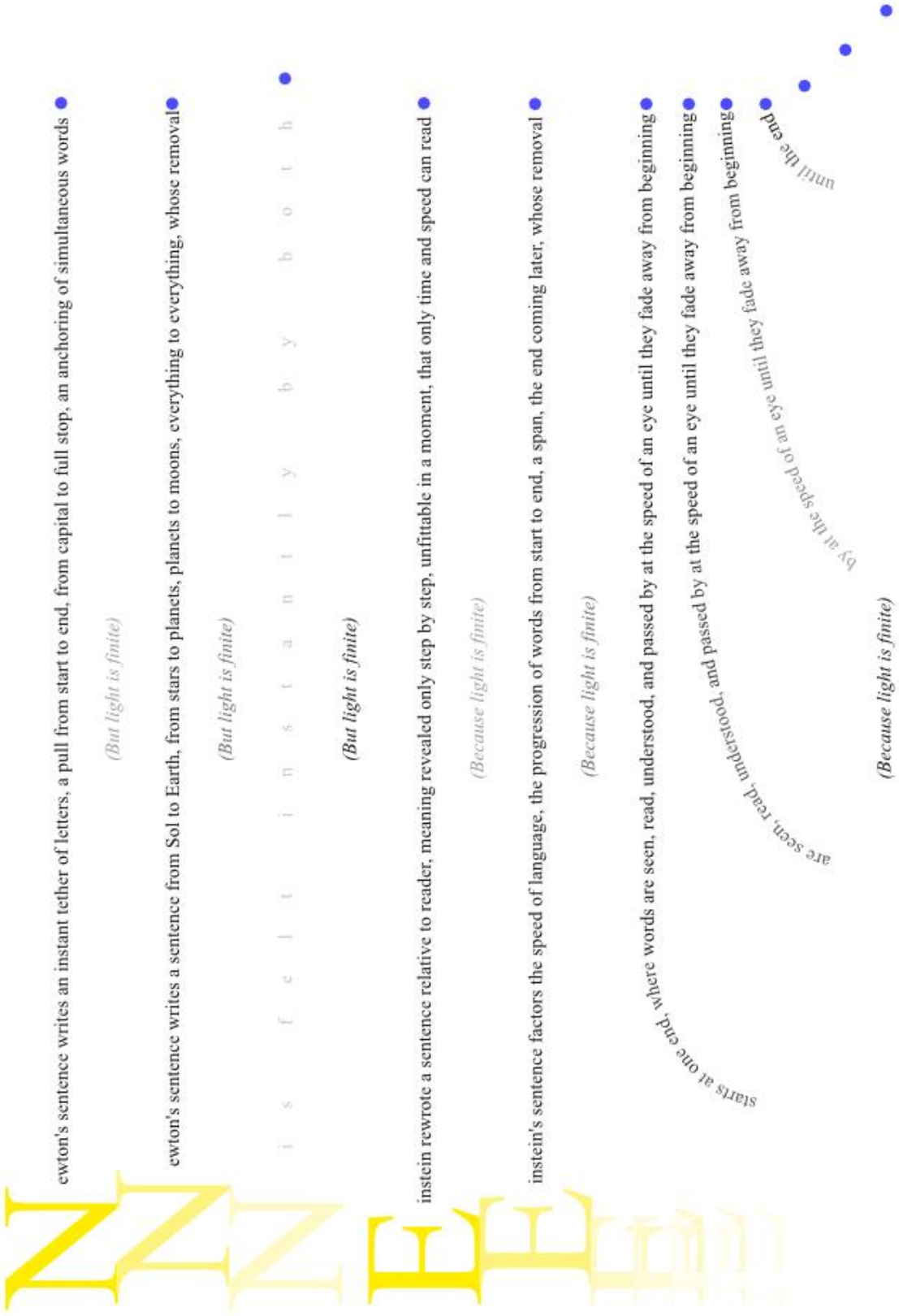
1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'You Relative to Me (Time).
3. Follow the on-screen instructions to begin.

6. You Relative to Me (Space)

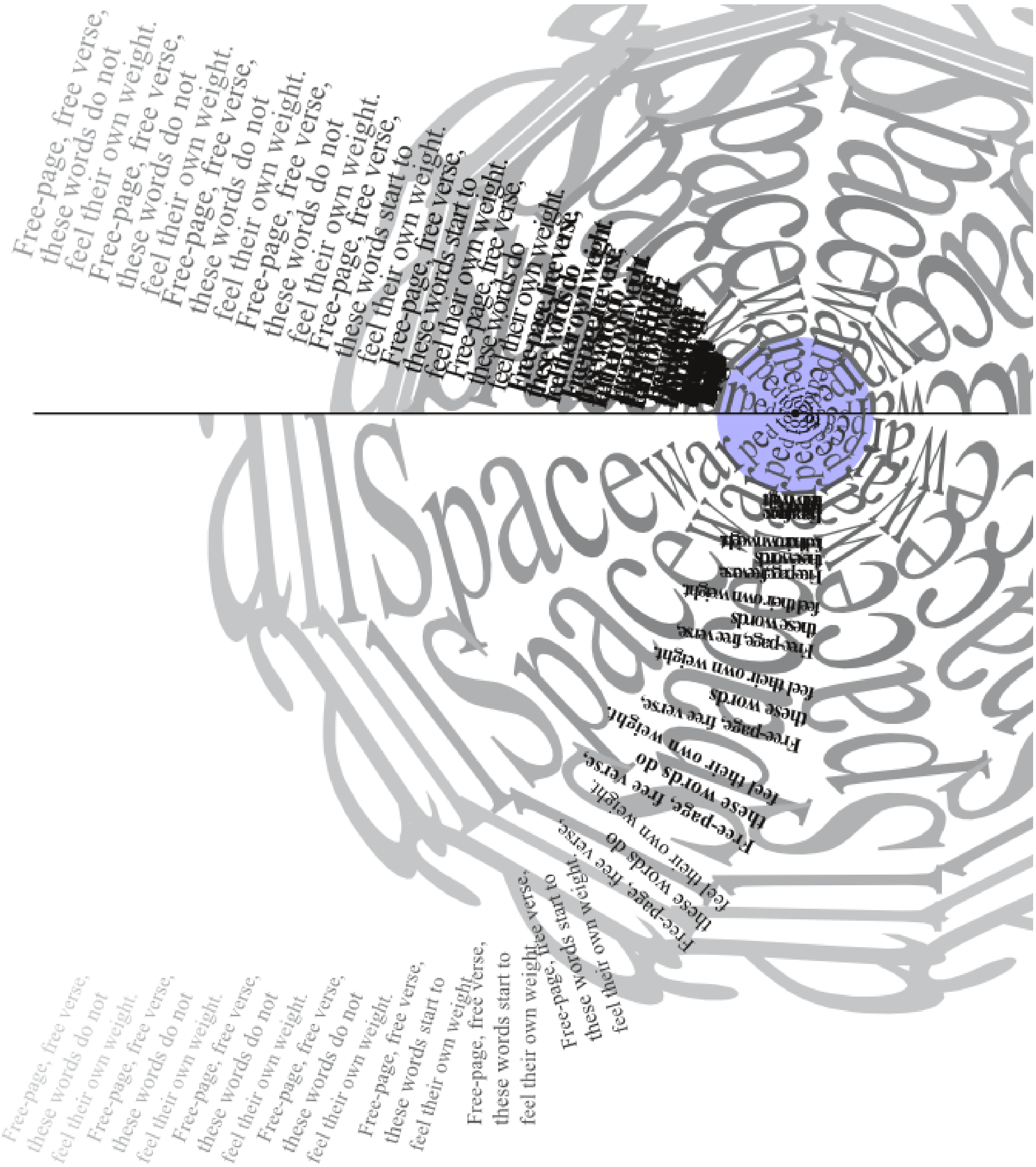
Please refer to the included CD-ROM to access this piece

1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'You Relative to Me (Time).
3. Follow the on-screen instructions to begin.

7. Light and Gravity



8. Freefall (The Happiest Thought)



9. The Doppler Effect

It is
letting go, drifting,
falling away from
you;
purely, loss, the
siphoning of
the will to
go on,
and my
faint trails
stretch thin,
to long
drawn
out
fragile
tendrils,
the ripple
so wide,
the
waves
so high
I ride
and
barely
feel
the
bob
bing
of
my
wei
ght
less
ship
as
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a
sta
tion
of
the
metro
bump
ed and
hurl
ed and
jostled,
I am
forced
to you by
the crowd
the stampede
who,
ignoring my
cries, squash
my voice
as I call
out to you,
the motion, the
force driving
me closer makes
me shrill, full
of
fear, alive and
empowered by the
raw energy
of the surge, each shriek
shifting from
strength to strength, pitch
by pitch, degree by
degree closer to you, degree by
degree upping the ante in
desperation, one degree by one
more primal, cornered
without a corner to call my own,
the hot rise between the shoving
seconds; well on my way to a scream
of blue murder

10. How to Travel Faster than Light (In Flatland)

From here, go

and **bend** the rules. Cheat. Take a shorter path than light, being unbound from length and breadth, and come to know depth, leaping through the third

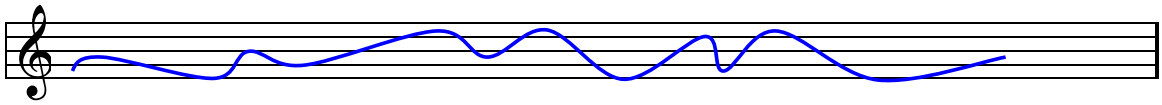
to here.

11. Double Slit: Part One

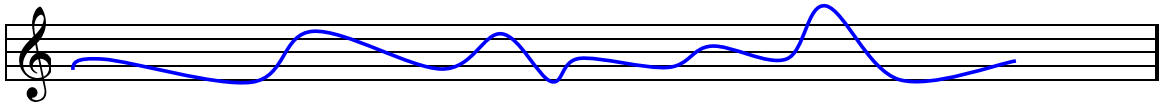
Please refer to the included CD-ROM to access this piece

1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'Double Slit: Part One'.
3. Follow the on-screen instructions to begin.

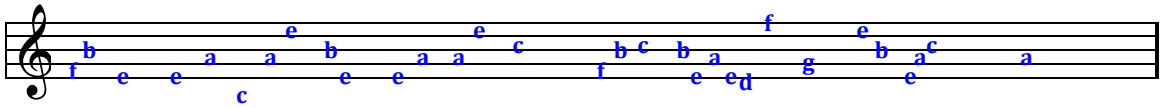
12. A Light Staccato



~~If wavelike, when blue light hits this metal bar, when current floods free electrons; there is no explanation.~~



~~If wavelike, it passes or reflects, nothing more, like water trying to chip away a wall; ineffective, inaccurate.~~



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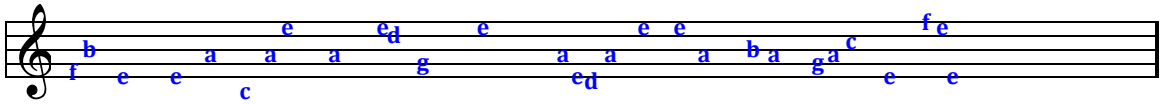

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13. Double Slit: Part Two

Please refer to the included CD-ROM to access this piece

1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'Double Slit: Part Two'.
3. Follow the on-screen instructions to begin.

2. Of Probability and Uncertainty

14. The Size of Little Things

.

Get your yardstick out
and measure that,
because I just wrote
millions of atoms
and ended a sentence
that never began.

And again.
Etc. etc. etc...

I gave it no capital
genesis, withheld
optic/neuro translation
subtracted past and
dragged the future
forever into now.

And yet I chose,
I kept preserved in
the moment a vastness
that would have dwarfed,
made words mere and
withered. That dot will

always say more
than I ever could
.

15. H

Please refer to the included CD-ROM to access this piece.

1. Insert the CD-ROM into your computer's disk drive.
2. Open the file entitled 'H'
3. Follow the on-screen instructions to begin.

16. Waltz of the Nuclei

Please refer to the included CD-ROM to access this piece

1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'Waltz of the Nuclei'.

Follow the on-screen instructions to begin.

17. ElectroMagnetism

Please refer to the included CD-ROM to access this piece

1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'ElectroMagnetism'.
3. Follow the on-screen instructions to begin.

18. The Voyage of Weak and Decay

Please refer to the included CD-ROM to access this piece

1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'The Voyage of Weak and Decay'.
3. Follow the on-screen instructions to begin.

19. The Graviton

Please refer to the included CD-ROM to access this piece

1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'The Graviton'.

Follow the on-screen instructions to begin.

20. Between the Slits

Please refer to the included CD-ROM to access this piece

1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'Between the Slits'.
3. Follow the on-screen instructions to begin.

21. When You Try to See/'As If It Were . . .'

Fire a beam of
Photons
or
Electrons
or
Quarks
(three for Mr…
the building blocks of
Protons
and
Neutrons)
or anything that makes
/
mediates
Matter/Force
the result
is always
the same
.

When you don't look
it does
both.
Everything
at once;
a *Superposition*.
If you try to see what
it does
you'll see only
one
or
the other;
possibilities
collapse.

In truth, when we say
Wave
/
Particle
we only mean it 'behaves'
'as if it were a
. . .'

22. The Differance

Please refer to the included CD-ROM to access this piece

1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'The Difference'.
3. Follow the on-screen instructions to begin.

23. The Wavicle

over here and over here and over here and over here and over here and over here and over here and over here
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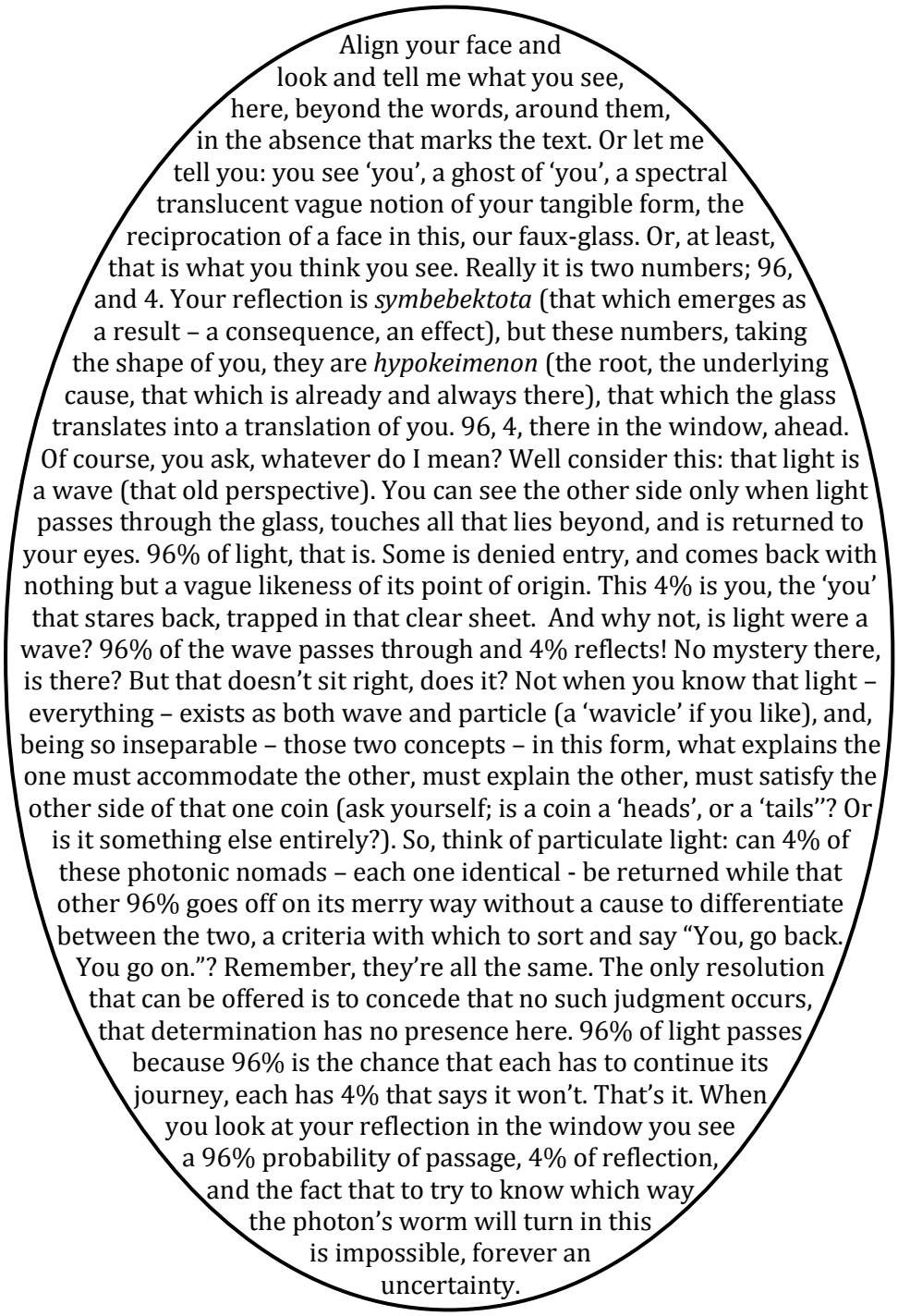
Probably.

24. Schrödinger's Cat

As you can **imagine**, once you have opened the **box** and looked **in**side, **which** you now do, tentatively, unsure of what **is** there, past these newly un**sealed** walls, you will see the **cat** alive, **with** not so much as **a** scratch to be found from the **gun** that still sits **aimed** and **at**tached to the apparatus; silent **it** sits, still **connected to** its **levers** that would have bowed **and** obeyed the whims of **a Geiger counter**, which, **with**out a second thought, if it **had** sniffed the scent of its prey – that **mass of radioactive material** – that hid **nearby**, would have growled **its** rough, **half**hearted, **life**less orders to **its** artificial hand to pull and take a **chance** shot, the act **of** thoughtless action that would **decay** the silence in an instant, and **is**, though so simple, undisturbed, silent; the **50/50** lands favourably (for our feline friend), in the blue; a life found, only because you looked.

25. Quantum Window



26. Uncertainty

Please refer to the included CD-ROM to access this piece

1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'Uncertainty'.
3. Follow the on-screen instructions to begin.

27. Cogito Ergo Sum Over History

Please refer to the included CD-ROM to access this piece

1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'Cogito Ergo Sum Over History'.
3. Follow the on-screen instructions to begin.

28. Antimatter

Please refer to the included CD-ROM to access this piece

1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'Antimatter'.
3. Follow the on-screen instructions to begin.

3. Of Universality

29. It's Kind of Like the Theme to Star Wars

Please refer to the included CD-ROM to access this piece

1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'It's Kind of Like the Theme to Star Wars'.
3. Follow the on-screen instructions to begin.

30a. Superforce (Side A)

Please refer to the included CD-ROM to access this piece

1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'Superforce (Side A)'.
3. Follow the on-screen instructions to begin.

30b. Superforce (Side B)

Please refer to the included CD-ROM to access this piece

1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'Superforce (Side B)'.
3. Follow the on-screen instructions to begin.

31. Afterimage

Please refer to the included CD-ROM to access this piece

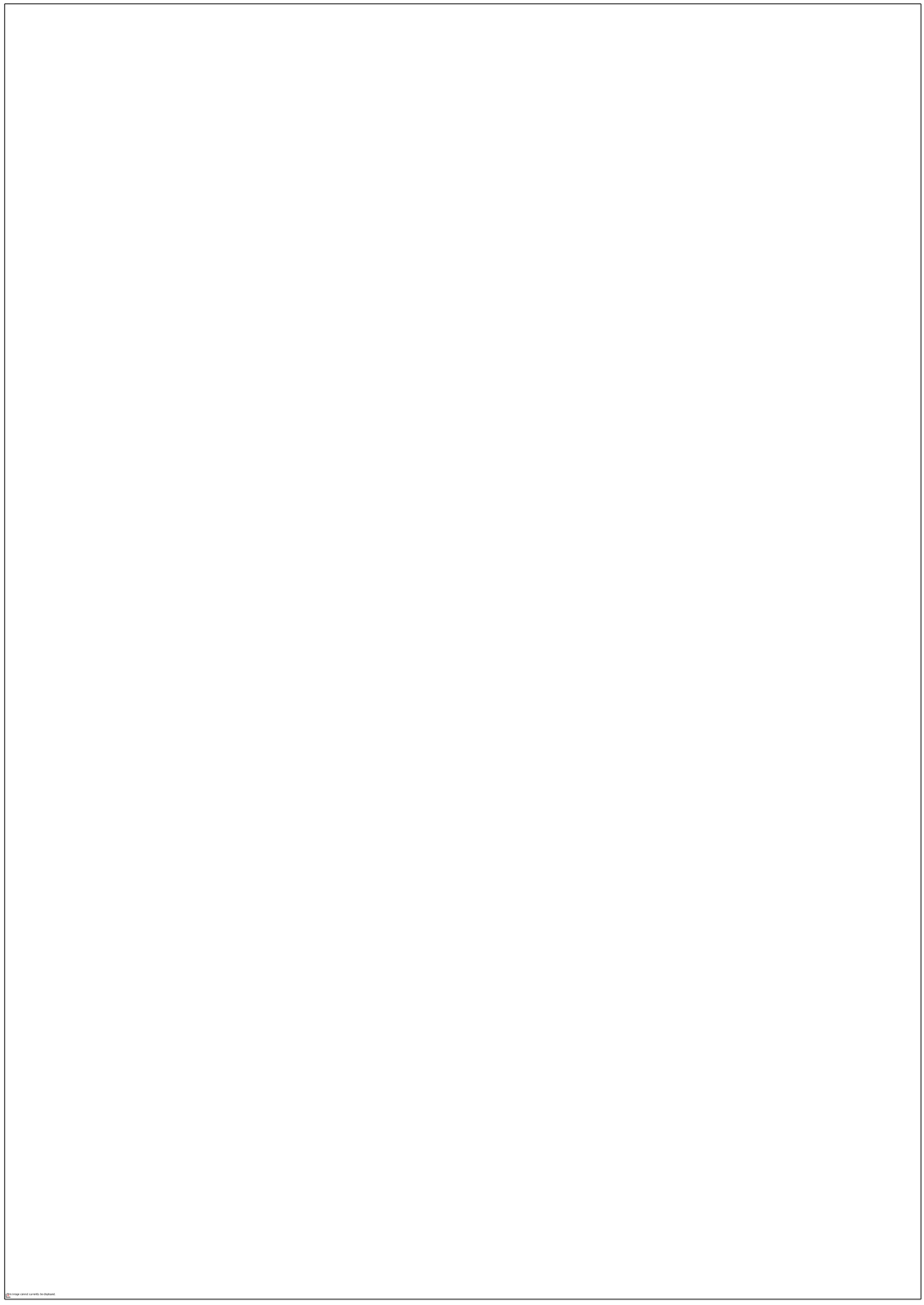
1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'Afterimage'.
3. Follow the on-screen instructions to begin.

32. Starbeast

Please refer to the included CD-ROM to access this piece

1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'Starbeast'.
3. Follow the on-screen instructions to begin.

33. Black Hole

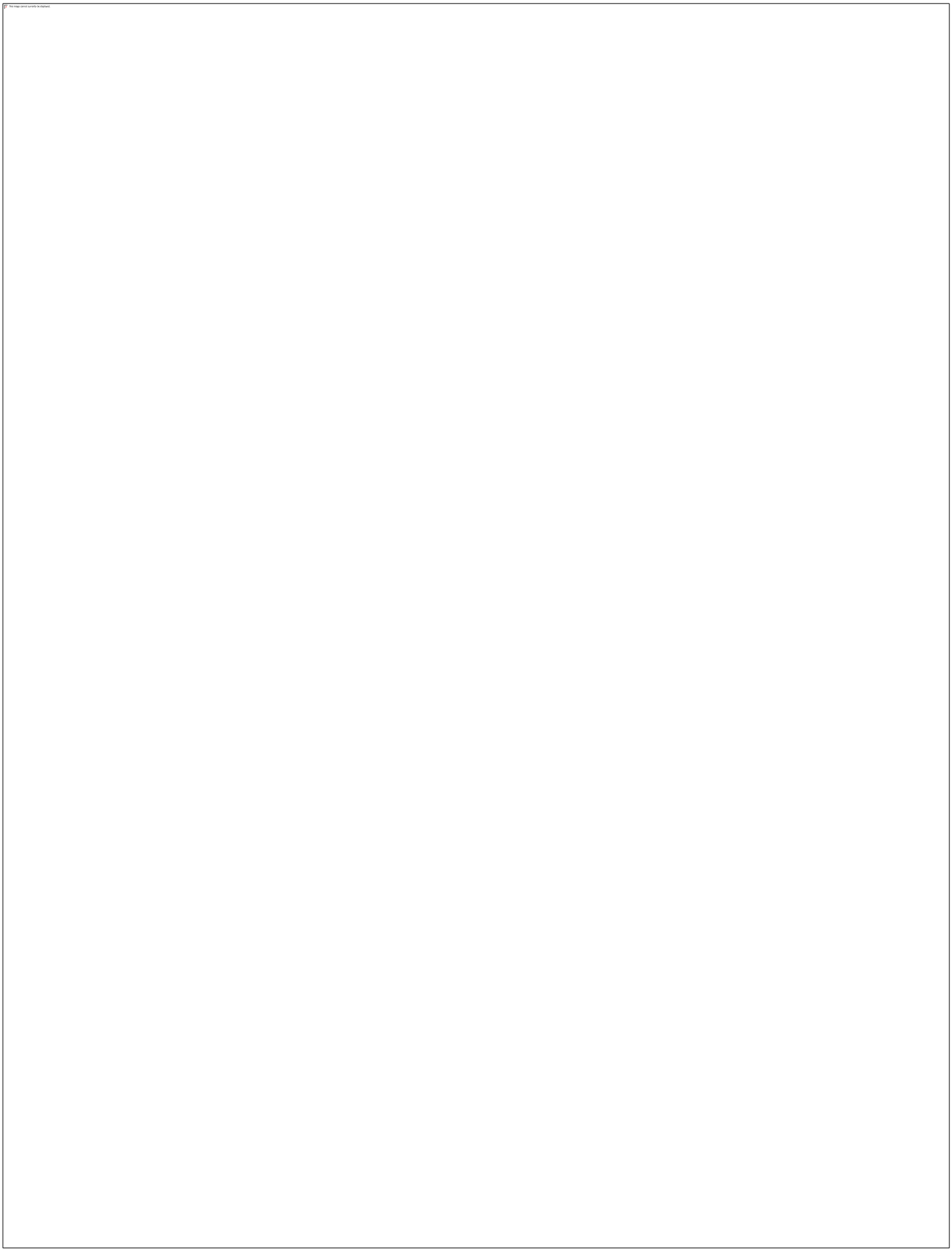


34. Holding Together/Pushing Apart

Please refer to the included CD-ROM to access this piece

1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'Holding Together/Pushing Apart'.
3. Follow the on-screen instructions to begin.

35. Mr. Higgs Takes a Run in the Ocean



36a. String Theory (Side A)

36b. String Theory (Side B)

37a. M-Theory (Side A)

Please refer to the included CD-ROM to access this piece

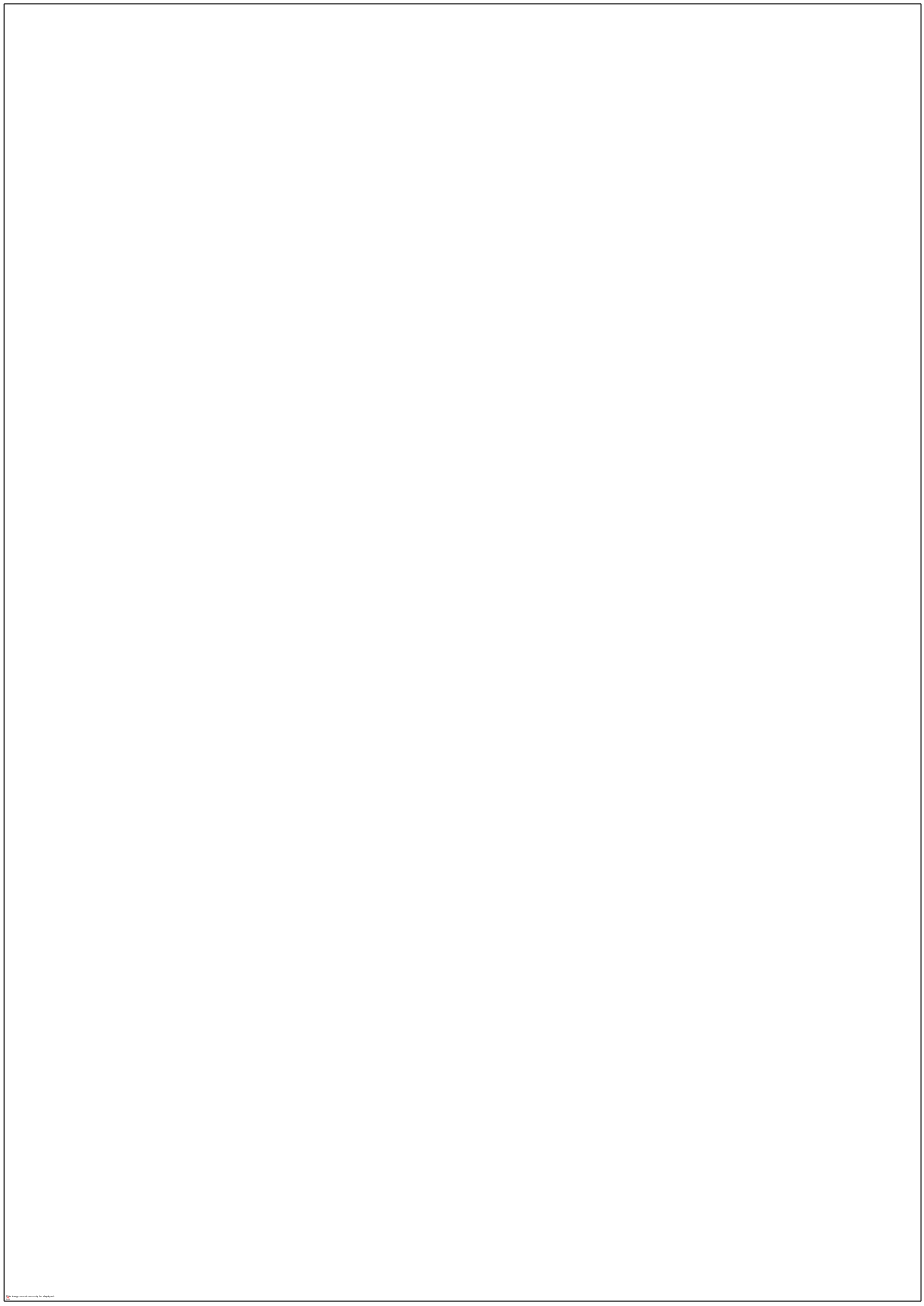
1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'M-Theory (Side A)'.
3. Follow the on-screen instructions to begin.

37b. M-Theory (Side B)

Please refer to the included CD-ROM to access this piece

1. Insert the CD into your computer's disk drive.
2. Open the file entitled 'M-Theory (Side B)'.
3. Follow the on-screen instructions to begin.

38. Linguistic Multiverse



39. Art/ /Science

Our greatest pleasure
[ ] lies in that virgin
blankness [
] beyond
the borderlands [
] that
untouched potential
with which we, with closed eyes,
[
] craft our possibilities,
our door [
] out, away for a while,
[ ]
where we will not walk [
]
to keep it free, alive, [
] untouched
and undefined, [
] preserved from
the mundanity [
] of becoming
[ ] real [ ] **.**

Our [ ]
greatest goal [
] to which we wind our way
ever onwards seeking [
] where the answers
to our story sleep [

]
armed with reason
and rationale [
] unlocking our place,
taking us [ ]
through our roots, the stars,
[ ] so far
away, entrusted with an awe
[ ] no longer
secret, myth, hearsay [
] but open, known
as wonder, free [
] of that oldest fear,
granted status; [
a [ ] sublime fact **.**

Part Two: Commentary

Chapter 1: Interactions of Science and Poetry

The contemporary relationship between science and poetry is perhaps best summarized by Paul Cantor in his essay 'The Scientist and the Poet':

> Poets generally seem to be unsympathetic to science; they question its capacity to tell us the full truth about the world. Typically, poets claim that science offers us only abstractions, and destroys the living phenomena it purports to study in the very process of analyzing them into their separate (and hence lifeless) parts . . . To the scientist, the poet seems to have his head up in the clouds, indulging in fantastic visions of what might be and losing sight of the way things really are.[2]

Several excellent examples of these attitudes are noted in Richard Dawkins' book *Unweaving the Rainbow*, such as novelist Fay Weldon's *Daily Telegraph* attack on scientists:

> You never even tried to answer the questions we all asked when we were six. Where did Aunt Maud go when she died? Where was she before she was born? . . . You think these questions are simplistic and embarrassing, but they're the ones that interest us. And who cares about half a second after the Big Bang; what about half a second before? . . . The scientists just can't face the idea of a variable universe. We can.[3]

And from scientists, those involved in the arts face remarks such as those of John Carey, writing in his preface to the *Faber Book of Science*:

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[2] Paul A. Cantor, 'The Scientist and the Poet', in The New Atlantis, Winter 2004, http://www.thenewatlantis.com/publications/the-scientist-and-the-poet.
[3] Richard Dawkins, *Unweaving the Rainbow*, (London: Penguin, 2006) p.33.

> Though most academics are wary of saying it straight out, the consensus seems to be that arts courses are popular because they are easier, and that most arts students would simply not be up to the intellectual demands of a science course.[4]

These attitudes are by no means universal. Niels Bohr, one of the founders of quantum mechanics, once remarked that 'when it comes to atoms language can be used only as in poetry', and British science journalist Simon Jenkins said in an interview with Richard Dawkins that 'I can think of very few science books I've read that I've called useful. What they've been is wonderful. They've made me feel that the world around me is a much fuller much more wonderful, much more awesome place than I ever realized it was.'[5] It is not hard to find scientists who enjoy and praise and even engage in the writing of poetry, nor is it hard to find writers with similar feelings towards the sciences, which makes it all the more bizarre that these views do not have the significant influence the more negative, critical, and vitriolic views do on the relationship between science and poetry.

De Rerum Natura

One of the earliest examples of the use of poetry as a vehicle for the expression of the scientific knowledge emerged from the work of the Greek philosopher Epicurus. 'On the Nature of Things' is an epic poem penned by the Roman poet Lucretius some 200 years after Epicurus'. In his essay ' Lucretius and Greek Philosophy', James Warren describes the role Lucretius plays in his poetic writing of Epicurean philosophies:

[4] Richard Dawkins, *Unweaving the Rainbow*, p.35.
[5] Richard Dawkins, *Unweaving the Rainbow,* p.37.

> Lucretius offers himself as a conduit and translator to Rome of Greek ideas. He is a translator not in the sense of merely rendering an original Greek text into Latin. Rather, he introduces, packages and explains Greek thought for a new culture and time . . . He acts as a filter of Greek thought, admitting only those ideas which are conducive to the goal of understanding the universe correctly.[6]

One of the clearest and most significant aspects of Lucretius' text is the emphasis he places on abandoning intellectual subservience to supernatural deities, replacing them with a desire to seek out true knowledge about the natural world. In Book One, lines 62-72, he praises Epicurus for these very efforts while condemning religious obedience:

> When human life lay foul for all to see
> Upon the earth, crushed by the burden of religion,
> Religion which from heaven's firmament
> Displayed its face, its ghastly countenance,
> Lowering above mankind, the first who dared
> raise mortal eyes against it was a man of Greece.
> He was not cowed by fables of the gods
> Or thunderbolts or heaven's threatening roar,
> But they the more spurred on his ardent soul
> Yearning to be the first to break apart
> The bolts of nature's gates and throw them open.
> Therefore his lively intellect prevailed
> And forth he marched, advancing onwards far
> Beyond the flaming ramparts of the world,
> And voyaged in mind throughout infinity,
> Whence he victorious back in triumph brings

[6] James Warren, 'Lucretius and Greek Philosophy', from *The Cambridge Companion to Lucretius*, ed. by Stuart Gillespie and Philip Hardie (Cambridge: Cambridge University Press, 2007) p.19.

> Report of what can be and what cannot
> And in what manner each thing has a power
> That's limited, and deep-set boundary stone.[7]

Here, Lucretius invokes powerful images of triumph in the defiance of superstition. Discussing this passage, Melville, in his introduction, notes:

> The heroism of this revolt in the name of earth and humanity against the empty tyranny of the gods goes closely . . . with Lucretius' poetic empiricism, which constantly recalls us from the mists and darkness of false belief to the plain light of scientific reasoning.[8]

On one side the reader is presented with 'religion', described using language that invokes constriction and oppression, while science is cast in the role of liberator aiming to 'break apart the bolts of nature's gates and throw them open'. Commenting on the influence of Epicurus on the work, Melville observes:

> Epicureanism is in one sense a negative philosophy, in that the emphasis falls on removing the confusions and delusions of unphilosophic humanity . . . It's central metaphors are of purging and liberating, freeing people from complex accretions of popular belief . . . It shares this stance of heroic removal of superstition and nonsense with much of the rhetoric of modern science.[9]

A little later, in lines 146-158, Lucretius' tone changes:

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[7] Lucretius, *On the Nature of the Universe,* (trans.) Robert Melville (New York: Oxford University Press, 2008) p.5.
[8] Lucretius, *On the Nature of the Universe*. From Ronald Melville's 'Introduction', p. xxx.
[9] Lucretius, *On the Nature of the Universe*. From Ronald Melville's 'Introduction', p. xxviii.

> We start then from her first great principle
> That nothing ever by divine power comes from nothing.
> For sure fear holds so much the minds of men
> Because they see many things happen in earth and sky
> Of which they can no means see the causes,
> And think them to be done by power divine.
> So when we have seen that nothing created
> From nothing, we shall at once discern more clearly
> The object of our search, both the source from which each thing
> Can be created, and the manner in which
> Things come into being without the aid of gods.[10]

Here Lucretius, speaks in favor of the scientific method, drifting effortlessly from the use of passionate imagery to calm, logical, and axiomatic discussion. This shift marks the passing of the battle to science presenting its credentials as successor through rational discourse and deductive reasoning, coolly dismissing religious superstitions as unnecessary, as phenomena 'of which they can no means see the causes' may become understood through means of scientific investigation.

In the first passage above, Lucretius makes an important point concerning the nature of physical research in the lines 'Whence he in victorious triumph brings / report of what can be and what cannot'. Here Lucretius lays out poetically one of the most important axioms of scientific enquiry: that there are things that are possible, there are things that are impossible, and hence, there must also be laws that determine what is possible and what is not possible in nature. As Lucretius puts it:

[10] Lucretius, *On the Nature of the Universe,* p.7.

> If you know these things well, you'll see at once
> That nature is free, no slave to master's proud;
> That nature by herself all things performs
> By her own will and without the aid of gods.[11]

It is to be expected that many of the scientific principles discussed in Lucretius' poem are outdated, but he does provide through poetry some valuable physical insights, such as his treatment of matter and void and their relationship to weight and density in Book One, lines 358-367:

> Lastly, why do we see some things weigh heavier
> Than others though their volume is the same?
> For if there is as much matter in a ball of wool
> As there is in lead, the weight must be the same,
> Since it is the function of matter to press downwards.
> But void, by contrast, stays forever weightless.
> Therefore a thing of equal size but lighter
> Declares itself to have more void inside it,
> But the heavier by contrast makes proclaim
> That it has more matter in it and much less void.[12]

While his descriptions of matter and void may be, by modern standards, simplistic, Lucretius correctly explains in very clear terms the principles of density and how this makes objects of the same volume differ in their weight in very clear terms. Elsewhere, in Book Two, lines 80-85 we find yet an example of a physical principle that would not be scientifically named for another few centuries:

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[11] Lucretius, *On the Nature of the Universe*, p.67.
[12] Lucretius, *On the Nature of the Universe*, p.13.

> Now if you think that atoms can be at rest
> And can by resting beget new movements in things,
> You are lost, and wander very far from truth.
> For since the atoms wander through the void,
> All must be driven either by their own weight
> Or by some chance blow from another atom.
> For often when as they move, they meet and clash,
> They leap apart at once in different directions.
> No wonder, since they are extremely hard
> And solid, and there is nothing behind to stop them.[13]

Though Lucretius refers only to atoms, the principle here – that objects move 'either by their own weight / or by some chance blow from another atom' – is better known today as Newton's first law of motion. This is science being expressed, explained, and celebrated through poetry. As Monte Johnson and Catherine Wilson note in their essay 'Lucretius and the History of Science':

> Both the atomic reality alleged to underlie the appearances and self-sufficiency of nature forcefully asserted by Lucretius exercised a powerful influence on modern science, and his name was still being invoked in scientific contexts as late as the nineteenth century, with his influence formally acknowledged well into the twentieth.[14]

Lucretius was correct that the goal of science is to 'report what can be and what cannot'. It is an essential part of science as a discipline and as a process that that it continually refutes itself in order to function. In other disciplines – the

[13] Lucretius, *On the Nature of the Universe*, p.38.
[14] Monte Johnson and Catherine Wilson, 'Lucretius and the History of Science', from *The Cambridge Companion to Lucretius*, (ed.) Stuart Gillespie and Philip Hardie, (New York: Cambridge University Press, 2007) p.132.

arts/humanities, for example – those involved are trained to think with a greater degree of flexibility: there may be many wrong answers, but there may also be many different right answers. This divergence between their the modes of thinking – empirically and interpretively – may have no small role to play in the difficulties between the sciences and the arts/humanities today.

The Enlightenment Attitude

With the scientific revolution that accompanied the Renaissance, the relationship between poetry and science continued with the same kind of positivity as can be found in Lucretius. A significant example of this is Alexander Pope's poem 'An Essay on Man', which not only praises the sciences, but also provides insight into the later deterioration of relations between the two disciplines. Evidence of Pope's admiration for scientific research can be clearly seen in the epitaph he penned for Sir Isaac Newton: 'Nature and nature's laws lay hid in night; / God said let Newton be and all was light.'

Despite being largely concerned with ethics, 'An Essay on Man' contains references to the importance of scientific study, specifically Epistles I and II. In the first stanza of Epistle I we see a tone very similar to that of Lucretius:

> He, who through vast immensity can pierce,
> See worlds on worlds compose one universe,
> Observe how system into system runs,
> What other planets circle other suns,
> What varied being peoples every star,
> May tell why Heav'n has made us as we are.[15]

[15] Alexander Pope, 'An Essay on Man', from *The Major Works* (New York: Oxford University Press, 2008), pp.272-3.

In this we can see, from the outset, a willingness to accept the scientific truth of the heliocentric solar system, the existence of other planets, and the possibility of life on other worlds. Here, the understanding of the universe and its various systems are recognised by Pope as the essence of the universe-as-divine-structure and as the only way to understand ourselves as a species within that universe; as A. Hamilton Thompson points out, for Pope 'God, not man, upholds the chain of being in which man is a link'[16]. Despite his theism, there is a similarity to Lucretius in how he champions science as a way of triumphing over fear and darkness. This emphasis is repeated several times throughout the piece. In the second stanza of the fifth section Pope writes:

> "No, ('tis replied) the first Almighty Cause
> Acts not by partial, but by gen'ral laws;
> Th' exceptions few; some change since all began:
> And what created perfect?"—Why then man?
> If the great end be human happiness,
> Then Nature deviates; and can man do less?
> As much that end a constant course requires
> Of show'rs and sunshine, as of man's desires;
> As much eternal springs and cloudless skies,
> As men for ever temp'rate, calm, and wise.
> If plagues or earthquakes break not Heav'n's design,
> Why then a Borgia, or a Catiline?
> Who knows but he, whose hand the lightning forms,
> Who heaves old ocean, and who wings the storms,
> Pours fierce ambition in a Cæsar's mind,

[16] Alexander Pope, ed. by A. Hamilton Thompson, *Essay on Man* (Cambridge: Cambridge University Press, 1913), from A. Hamilton Thompson's Analysis of the Poem, p. xxiii.

> Or turns young Ammon loose to scourge mankind?
> From pride, from pride, our very reas'ning springs;
> Account for moral, as for nat'ral things:
> Why charge we Heav'n in those, in these acquit?
> In both, to reason right is to submit.[17]

Pope de-centres the human, proposing a view of a humanity that is not privileged and special, above and apart from the rest of nature, but an equal part of it, governed by the same laws. Logically, as Earth is not the centre of the universe, then the nature of that universe is not centred around humanity.

Epistle II, compared to the first, is somewhat more cautious in its praise of science, best summed up in the second and fourth stanzas of the first section:

> Go, wondrous creature! mount where science guides,
> Go, measure earth, weigh air, and state the tides;
> Instruct the planets in what orbs to run,
> Correct old time, and regulate the sun;
> Go, soar with Plato to th' empyreal sphere,
> To the first good, first perfect, and first fair;
> Or tread the mazy round his follow'rs trod,
> And quitting sense call imitating God;
> As Eastern priests in giddy circles run,
> And turn their heads to imitate the sun.
> Go, teach Eternal Wisdom how to rule—
> Then drop into thyself, and be a fool!
> [. . .]
> Could he, whose rules the rapid comet bind,
> Describe or fix one movement of his mind?
> Who saw its fires here rise, and there descend,
> Explain his own beginning, or his end?

[17] Alexander Pope, 'An Essay on Man', from *The Major Works,* p.276.

> Alas what wonder! Man's superior part
> Uncheck'd may rise, and climb from art to art;
> But when his own great work is but begun,
> What Reason weaves, by Passion is undone.[18]

Where once Pope had likened scientific understanding to a moving toward the heavenly, he now seems to warn against this pursuit too greatly as something not intended for humanity. To do so, Pope seems to say, is to presume to assert humanity over nature, to presume to 'instruct the planets', to 'correct old time', and 'regulate the sun', summing this up with more than a hint of mockery as teaching 'Eternal Wisdom how to rule.' In his analysis of this section, A. Hamilton Thompson writes:

> Human intelligence and reason may accomplish much, but man's lower part with its passions makes all the attempts of his superior part mere beginnings. Modesty is therefore necessary to the pursuit of science: man must disrobe his knowledge of all that is merely an excuse to exalt his own powers; and when this is done, he will see their limitations and the actual insignificance of human capacity.[19]

After taking the time in Epistle I to laud scientific enquiry, here Pope, without directly criticising science, diminishes its value in subservience to religion.

Pope agrees that there are things that science can explain, but asserts there are also things that are inherently beyond it – the 'movement' of the mind, etc. – and that science would be arrogant to believe that it could. It is not without a hint of irony that Pope writes that 'man's superior part unchecked may rise . . .

[18] Alexander Pope, 'An Essay on Man', from *The Major Works,* pp.281-2.
[19] Alexander Pope, *Essay on Man*, from A. Hamilton Thompson's Analysis of the Poem, p. xxviii.

what Reason weaves by Passion is undone', which is exactly what is happening in Pope's writing itself. For Pope the existence and authority of the Christian deity is not only automatically assumed and accepted, it becomes the framework within which science must situate itself. Throughout 'An Essay on Man' God is repeatedly invoked and referenced as the prime mover, the governor of natural laws. This is embodied in the final couplet of the second epistle: 'See! and confess, one comfort still must rise, / 'Tis this: Though man's a fool, yet God is wise.' Pope cannot fully champion the pursuit of science without subverting it to his deity, and science itself cannot produce knowledge if its discoveries are not allowed to reshape the pre-existing worldview. Lucretius' work, on the other hand, lacks these constraints. In his essay 'Pope and Lucretius: Observations on "An Essay on Man", Bernard Fabian notes that Pope wrote to Jonathan Swift while composing the piece saying 'Whether I can proceed in the same grave march like Lucretius, or must descend to the gaieties of Horace, I know not.'[20] Lucretius and Horace here are revealed to have put Pope in an uncomfortable position. David Hopkins, in his essay 'English Voices of Lucretius' elaborates on this dilemma:

> Pope is both attracted by Lucretius' dogmatically assertive tone, and, in complex dialectic of engagement, unwilling to align himself with its insistence and evangelical commitment – not merely because it does not accord with his own Christianity, but because he would not align himself with any totalising philosophical certainty . . . Pope's *Essay*, like *Paradise*

[20] Bernard Fabian, 'Pope and Lucretius: Observations on 'An Essay on Man"', cited in Joe Moshenka's *Feeling Pleasures: The Sense of Touch in Renaissance England* (Oxford: Oxford University Press, 2014), p.280.

> *Lost* before it, signals its distance from Lucretius *at the same time* as imitating and rendering Lucretius' 'grave march'. [21]

Pope cannot commit to his admiration of Lucretius, and his opposition to Lucretius' views leaves the *Essay* likewise unable to fully praise or criticise science. Pope's work is valuable, because it foreshadows two important reasons for the coming deterioration of relations between poetry and the sciences. The first is that Pope, as a poet, while praising of science, places himself above science, feeling entitled to judge the place of science because of his religious convictions. The second lies in Pope's opposition to the elevating of humanity to the role of being a dominator of nature, which, in the following years, many scientists would, in the following years, hold to be the very purpose of science.

Romantic Troubles

The late 18th and early 19th centuries mark the stage at which relations between the two disciplines really began to deteriorate, owing largely to the attitude of the scientists of the Royal Society, and to the subsequent reaction of certain poets, such as William Blake and John Keats. Blake's anti-scientific stance can be seen clearly in poems such as 'The Voice of the Devil', from 'The Marriage of Heaven and Hell', which features the line 'Those who restrain desire, do so because theirs is weak enough to be restrained; and the restrainer or Reason usurps its place and governs the unwilling.'[22] Here Blake clearly positions

[21] David Hopkins, 'The English Voices of Lucretius from Lady Hutchinson to John Mason Good', from *The Cambridge Companion to Lucretius*, ed. by Stuart Gillespie and Philip Hardie (Cambridge: Cambridge University Press, 2007), p.272.
[22] William Blake, ' The Voice of the Devil', from *The Selected Poems of William Blake* (Ware: Wordsworth Editions, 2000) pp.196-7.

'reason' as something that suppresses what he sees as the divinity of 'desire', and, therefore, as an un-Godly force. This theme returns again later in 'The Marriage of Heaven and Hell', in the third section entitled 'A Memorable Fancy'[23], in which he describes Hell perpetuating its influence by means of a printing house manned by dragon-men, vipers, eagles/eagle-men, and lions, witnessing 'the method in which knowledge is transmitted from generation to generation.' Blake specifically uses the word 'knowledge' and positions it as a product of the denizens of Hell itself.

One scientist for whom Blake had particular disdain was Isaac Newton. In his poem 'To Thomas Butts' ('With Happiness stretch'd across the hills')[24], he concludes the piece with a particularly disdainful remark aimed at Isaac Newton – 'May God us keep / From single vision, and Newton's sleep.' Blake seems to take the cautionary tone found in Pope's 'Essay on Man' one step further into complete contempt to science, retreating back into the religious 'darkness' that Lucretius firmly opposed. This continues in 'A Vision of Albion':

> I see the Four-fold Man, The Humanity in deadly sleep
> And its fallen Emanation, The Spectre and its cruel Shadow.
> I see the Past, Present and Future existing all at once
> Before me. O Divine Spirit, sustain me on thy wings,
> That I may awake Albion from his long and cold repose;
> For Bacon and Newton, sheathed in dismal steel, their terrors hang
> Like iron scourges over Albion: Reasonings like vast Serpents
> Infold around my limbs, bruising my minute articulations.

[23] William Blake, 'A Memorable Fancy', from *The Selected Poems of William Blake* p.202.
[24] William Blake, ' With Happiness stretch'd across the hills', from *The Selected Poems of William Blake* pp.146-8.

> I turn my eyes to the Schools and Universities of Europe
> And there behold the Loom of Lock, whose Woof rages dire,
> Washed by the Water-wheels of Newton: black the cloth
> In heavy wreathes folds over every Nation: cruel Works
> Of many Wheels I view, wheel without wheel, with cogs tyrannic
> Moving by compulsion each other, not as those in Eden, which,
> Wheel within Wheel, in freedom resolve in harmony and peace.[25]

Blake condemns the works of Isaac Newton and Bacon as oppressive and harmful forces operating in society, urging a return towards the 'harmony and peace' of Eden. For Blake, the knowledge that Newton and Bacon contributed to science was 'dismal', referring to them as 'terrors' that 'hang like iron scourges'. We see this attitude several other times in the 'Jerusalem' sequence, such as the opening lines of 'The Fury of Los':

> They saw their wheels rising up poisonous against Albion:
> Urizen cold and scientific[26]

Blake clearly stands in direct opposition to the kind of thinking the Lucretius applauded.

Other Romantic poets seem not to object so much to scientific activity itself, but to a perception of science, namely one that demystifies nature and, in doing so, drains it of its beauty. This can be seen in the penultimate stanza of Wordsworth's poem 'The Tables Turned':

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[25] William Blake, 'A Vision of Albion', from *The Selected Poems of William Blake* pp.336-7.
[26] William Blake, 'The Fury of Los', from *The Selected Poems of William Blake*, p.342.

> Sweet is the lore which Nature brings;
> Our meddling intellect
> Mis-shapes the beauteous forms of things:-
> We murder to dissect.[27]

This attitude occurs again in a passage from Keats' 'Lamia':

> Do not all charms fly
> At the mere touch of cold philosophy?
> There was an awful rainbow once in heaven:
> We know her woof, her texture; she is given
> In the dull catalogue of common things.
> Philosophy will clip an Angel's wings,
> Conquer all mysteries by rule and line,
> Empty the haunted air, and gnomed mine –
> Unweave a rainbow, as it erewhile made
> The tender-person'd Lamia melt into a shade.[28]

Here the objection is not directed towards science itself, but towards its tendency for reductionist reasoning. For Keats, science takes away that beauty of mystery itself, reducing the rainbow to a series of cold, dull, and emotionally detached statements. This is supported by an account given by Benjamin Haydon of a conversation between Keats and Charles Lamb at dinner. John Barnard notes that:

> At a dinner-party at Haydon's on 28 December 1817, Keats agreed with Lamb that Newton had 'destroyed the poetry of the rainbow, by reducing

[27] William Wordsworth, 'The Tables Turned', from *The Collected Poems of William Wordsworth* (London: Wordsworth Editions, 1995), pp.573-4.
[28] John Keats, 'Lamia', from *The Complete Poems* (London: Penguin Books, 2006), pp.414-433.

> it to a prism', and had drunk 'Newton's health, and confusion to mathematics' (*The Diary of B.R. Haydon,* ed. W.B. Pope [1960], II, p71). [29]

Examining this passage in *Science and Poetry,* Mary Midgley notes: 'should our only reaction to a diamond be to explain that it is just carbon, and to a rainbow to point out that it is just water . . . Keats thinks not.' Midgley asserts that it was not the Romantics who generated this view of science, but scientists themselves, especially the members of the Royal Society. She writes:

> Bacon repeatedly insisted that the aim of the new science must not be just to 'exert a gentle guidance over Nature's course' but 'to conquer and subdue her, to shake her to her foundations' . . . That victory would inaugurate something that he strangely called a 'truly masculine birth of time,' a new epoch which would subdue 'Nature with all her children, *to bind her to your service and make her your slave*.[30]

Midgley also quotes a passage from Joseph Glanvill's *The Vanity of Dogmatising* in which he expands Bacon's imagery:

> The Woman in us, still prosecutes a Deceit like that begun in the garden, and our understandings are wedded to an Eve, as fatal as the Mother of our miseries. And while things are judged according to their suitableness, or disagreement to the Gusto of the fond Feminine, we shall be as far from the tree of knowledge as from that guarded by the Cherubim.[31]

Keats' objection to science was because of these attitudes perpetuated by scientists themselves. What can be read as anti-science rhetoric in 'Lamia' can be

[29] John Barnard, from John Keats, *The Complete Poems*, p.697.
[30] Mary Midgley, *Science and Poetry* (Abigndon: Routledge Classics, 2006) p.56.
[31] Mary Midgley, *Science and Poetry*, p.68.

considered as the Romantic's opposition to the belief that humanity, through science, should conquer nature, and opposition to the misogynistic view of the feminine as the weak and deceitful. This fits in well within Keats' retelling of the Lamia myth, viewing the original myth as a 'piece of propaganda meant as a warning against love and, more particularly, a warning against women.'[32] As Midgley points out, 'educators in the Age of Reason not only typically ignored the development of feelings but often tried, so far as possible, to suppress them entirely.' Rather ironically, given the emphasis science today places on questioning and critiquing everything in order to ensure that evidence supports the validity of a theory (the scientific method), Keats is actually employing that same critical view towards science within his own society. In the context of Romantic attitudes to science, Midgley makes this important observation:

> At the time of the Romantic Revival what discredited it [science] most directly was its association with an attitude of fear and contempt for the imagination and for ordinary human feeling.[33]

Sadly, however much those views among both scientists and poets changed over the succeeding decades, the enmity between them that originates in this period continues to govern the relationship between the two disciplines.

A central problem is, as C.P. Snow states in his lecture 'The Two Cultures and the Scientific Revolution', 'the feelings of one pole become the anti-feelings of the other.'[34] Snow's lecture, which is commonly cited as a call for the

[32] Mary Midgley, *Science and Poetry,* p.70.
[33] Mary Midgley, *Science and Poetry*, p.67.
[34] C.P. Snow, *The Two Cultures and The Scientific Revolution* (New York: Cambridge University Press, 1961), p.12.

arts/humanities and the sciences to respectfully keep to their own field of study, actually states the complete opposite:

> This polarization is a sheer loss to us all. To us as people, and to our society, it is at the same time practical and intellectual and creative loss, and I repeat that it is false to imagine that those three considerations are clearly separable.[35]

As a scientist he spends much of his lecture defending science, but when it comes to defending literature he is often much more lackluster. He often makes comparisons between the 'scientific' – used mostly to describe those who agree with him – and the 'non-scientific' – used mainly to disparage those who do not share his views, as in this passage:

> Most of my scientific acquaintances think that there is something in it, and so do most of the practicing artists I know. But I have been argued with by non-scientists of strong down-to-earth interests.[36]

Robert Crawford, in his editor's introduction to the essay collection *Contemporary Poetry and Contemporary* Science, commenting on Mary Midgley's work, notes that this attitude was not uncommon:

> When the philosopher Mary Midgley writes her book *Science and Poetry* (2001), she uses the term 'poetry' to denote those elements of life which we assume to be unscientific. Midgley is far from alone in her misty use of

[35] C.P. Snow, *The Two Cultures and The Scientific Revolution*, p.12.
[36] C.P. Snow, *The Two Cultures and the Scientific Revolution*, p.9.

> the word. Many scientists use 'poetry' or 'poet' similarly; poets are people who haven't a clue.[37]

Simon Armitage, in his essay 'Modelling the Universe: Poetry, Science, and the Art of Metaphor' relates a story about attending a university course entitled *Astronomy for Poets* which had nothing with actual poetry or its relationship to that particular branch of science. He writes:

> 'Poet', in this context, was a euphemism for a fairly familiar character. Star-gazer might be a kind way of putting it. Amateur might be another. But above all, the word implied the inability to engage with the subject at the approved and accepted level. It isn't unusual, as a poet, to be associated with all kinds of scientific incompetence.[38]

An excellent example of this is Robert K. Logan's book *The Poetry of Physics and the Physics of Poetry,* which, in 329 pages, dedicates just one 8 page chapter to 'Poetry Influenced by the Scientific Revolution', which focuses more on the impact of the scientific revolution on the works of philosophers at the time, via oblique references to John Donne, Joseph Addison, and William Blake.[39] While we may sympathise with Armitage on this point, in the same piece he goes on to

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[37] Robert Crawford, 'Introduction', from *Contemporary Poetry and Contemporary Science*, ed. by Robert Crawford (Oxford: Oxford University Press, 2006), p.3.
[38] Simon Armitage, 'Modelling the Universe: Poetry, Science, and the Art of Metaphor', from *Contemporary Poetry and Contemporary Science*, p.111.
[39] Robert K. Logan, *The Poetry of Physics and the Physics of Poetry* (Singapore: World Scientific Publishing, 2010) pp.67-75. Logan's book is almost entirely a 'physics for amateurs' textbook, and what references to poetry there are in this chapter mainly amount to little more than dramatic window-dressing for the prose sections, particularly considering his claim that the opening four lines of Blake's 'Auguries of Innocence' ('To see a World in a grain of sand / And Heaven in a Wild Flower / Hold Infinity in the palm of your hand / and Eternity in an Hour') are an 'implicit support' of science, completely ignoring Blake's otherwise contemptible attitude towards science in many of his other works.

commit the same act of disciplinary self-superiority, this time directed by poetry towards science:

> Science didn't take man to the moon. It might have worked out the trigonometry, but it was a poetic dream that propelled us into the heavens to set foot on the lunar mass which has pushed and pulled at us from before we had eyes to see it . . . Poetry proposed the existence of the DNA double helix with its eye for detail, and poetry postulated the theory of relativity with its penchant for cryptic crosswords, and poetry produced the first light bulb because of its fear of the dark, and poetry learned how to create fire from friction because of its grumbling dislike of the cold and its fascination with the supernatural effects of combustion.[40]

Here Armitage takes some of the great techno-scientific achievements and tragedies, reduces the role of science itself to mere busywork, and makes the outlandish claim that the credit/responsibility for all of these, using exactly the same vague, obtuse, inaccurate, and unhelpful definition of 'poetry' as scientists do in the examples above.

The Kind of Poetry I Want

The 20th century Scottish poet Hugh MacDiarmid sought a return to Lucretian appreciation of science. Edwin Morgan describes him as:

> A strong believer in the unity of knowledge, and he refused to accept a split between the arts and the sciences . . . He wanted it all: vocabulary,

[40] Simon Armitage, 'Modelling the Universe: Poetry, Science, and the Art of Metaphor', from *Contemporary Poetry and Contemporary Science*, p.120.

> theories, facts . . . He had a large appetite for facts, and wanted to upgrade them, to make poetry.[41]

MacDiarmid's position on science and poetry are well demonstrated in his poem 'Poetry and Science'. From the first stanza:

> The rarity and value of scientific knowledge
> is little understood – even as people
> who are not botanists find it hard to believe
> special knowledge of the subject can add
> enormously to the aesthetic appreciation of flowers!
> Partly because in order to identify a plant
> you must study it very much more closely
> than you might otherwise have done, and in the process
> exquisite colours, proportions, and minute shapes spring to light
> too small to be ordinarily noted.[42]

For MacDiarmid, like Lucretius, knowledge of the scientific realities of an object do not 'unweave the rainbow', but are essential for being able to fully appreciate it poetically. In the second stanza he becomes much more explicit on this point:

> Wherefore I seek a poetry of facts. Even as
> the profound kinship of all living substance
> is made clear by the chemical route.
> Without some chemistry one is bound to remain
> forever a dumbfounded savage
> in the face of vital reactions.
> The beautiful relations

[41] Edwin Morgan, 'Poetry and Virtual Realities', from *Contemporary Poetry and Contemporary Science*, p.32.
[42] Hugh MacDiarmid, 'Poetry and Science' from *Selected Poetry*, ed, by Alan Riach and Michael Grieve (Manchester: Carcanet, 2004), pp.196-7.

shown only by biochemistry
replace a stupefied sense of wonder
with something more wonderful
because natural and understandable.
Nature is more wonderful
when it is at least partly understood.[43]

MacDiarmid rightly recognizes that an understanding of nature expands our capacity for appreciating its 'wonder' without having to contrive imaginative extensions. MacDiarmid makes this explicit in the final stanza:

He will understand why the biochemist
can speculate on the possibility
of the synthesis of life without feeling
that thereby he is shallow or blasphemous.
He will understand that, on the contrary,
he finds all the more[44]

Here, the 'biochemist' is not just a literal biochemist, but also a representation of the kind of poet MacDiarmid calls for, one who can 'speculate on the possibility of the synthesis of life' because they see how much more there is to that subject than they would be able to without that knowledge. A similar sentiment is echoed in another of his poems. 'The Kind of Poetry I Want', in which MacDiarmid calls for:

A poetry that never for a moment forgets
that if we study the position of the foetus
as it appears in about the ninth month

[43] Hugh MacDiarmid, 'Poetry and Science' from *Selected Poetry*, pp.196-7.
[44] Hugh MacDiarmid, 'Poetry and Science' from *Selected Poetry*, pp.196-7.

> of its development, we see the tiny body
> curled up with its head bowed over,
> the hands crossed, and the knees drawn up
> to permit the whole structure
> of bones, muscles, nerves,
> and arteries to fit comfortably
> into the cage or matrix.[45]

MacDiarmid calls for the same kind of poetic empiricism as Lucretius, demonstrating this through his poetic description of the functionality of the positioning of a fetus in the womb. Whereas Snow gives the impression that poets should be more like scientists, and people like Keats and Armitage giving the opposite view, MacDiarmid takes the attitude that science and poetry enhance each other. As MacDiarmid himself said, 'science seeks all, everywhere: and literature must follow suit – or cease to survive, save as a dope for inadequate minds.'[46]

John Baglow, in *Hugh MacDiarmid: The Poetry of Self*, criticizes 'The Kind of Poetry I Want' for failing to create the kind of poetry he idealizes in the piece. He writes:

> By describing the kind of poetry he wants, he is describing only his parameters; his use of bridge terms, for example, while giving a general idea of the bridge, tells us nothing about of the ideal poetry he is

[45] Hugh MacDiarmid, 'from The Kind of Poetry I Want' from *Selected Poetry*, p.208.
[46] Michael H. Whitworth, 'The Use of Science in MacDiarmid's Later Poetry' from *The Edinburgh Companion to Hugh MacDiarmid*, ed. Scott Lyall and Margery Palmer McCulloch(Edinburgh: Edinburgh University Press, 2011), p.98.

> projecting. What we have here is pure theory . . . The world of facts, which this poem is about, remains an abstraction.[47]

In his poem 'On a Raised Beach', MacDiarmid does overuse technical language initially which runs the risk of alienating readers:

> All is lithogenesis – or lochia
> carpolite fruit of the forbidden tree,
> stones blacker than any in the Caaba,
> cream-coloured caen-stone, chatoyant pieces,
> celadon and corbeau, bistre and beige,
> glaucous, hoar, enfouldered, cyathiform,
> making mere faculae of the sun and moon'). [48]

The technical language is densely stacked, and, to readers unfamiliar with these disciplines, the piece may seem daunting and inaccessible. What Morgan commends MacDiarmid for was he eagerness to:

> Gather together all the facts and theories and processes that generally interested him . . . I think he really did want to show that poetry and science could be brought together, but he could do it only on his own terms.[49]

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[47] John Baglow, *Hugh MacDiarmid: The Poetry of Self* (Quebec: McGill-Queen's University Press, 1987), p.202.
[48] Hugh MacDiarmid, 'On a Raised Beach' from *Selected Poetry*, p146-156. 'Lithogenesis' refers to the formation of sedimentary rock, 'lochia' refers to the vaginal discharge following a birth, 'chatoyant' is an optical 'cat's eye' characteristic found in gemstones, 'cyathiform' refers to something that is formed in a cup-like shape, and 'faculae' are bright granular structures observed on the surface of the sun, commonly associated with 'sun spots'.
[49] Edwin Morgan, 'Poetry and Virtual Realities', from *Contemporary Poetry and Contemporary Science*, p36-37.

The density of his use of scientific terminology does not seem to be merely a reflection of MacDiarmid only being able to write on his own terms, but instead becomes more of a deliberate choice. Michael H. Whitworth, in his essay 'The Use of Science in MacDiarmid's Later Poetry', notes:

> In 1933 [MacDiarmid] defended Paul Valéry for what one critic had described as 'indigestible lumps of scientific vocabulary' in his poetry. There was, he argued, no merit in everyday language, which he termed 'the jargon of average mentality'; there was no 'special virtue' [in] restricting our linguistic medium to a miserable fraction of our expressive resources.'[50]

The use of very specialized terminology in his poetry reflects a very earnest desire to unite poetry and science. Instead of a failure of MacDiarmid to truly achieve this, it may have more to do with his unwillingness to compromise any aspects of technicality for clarity and accessibility. Nevertheless, 'On A Raised Beach', amid its uncompromising use of jargon, includes several passages that are very reminiscent of Lucretius' work. At the beginning of the second stanza he writes:

> Today on this shingle shelf
> I understand this pensive reluctance so well,
> This not discommendable obstinacy,
> These contrivances of an inexpressive critical feeling,
> These stones with their resolve that Creation shall not be
> Injured by iconoclasts and quacks.[51]

[50] Michael H. Whitworth, 'The Use of Science in MacDiarmid's Later Poetry' from *The Edinburgh Companion to Hugh MacDiarmid*, p.97.
[51] Hugh MacDiarmid, 'On a Raised Beach' from *Selected Poetry*, p.146.

MacDiarmid uses the stones to decenter humanity. Just as Lucretius did in *De Rerum Natura*, MacDiarmid points out through these stones that these processes exist independently of any human belief, perspective, or opinion; that they 'are' whether one wishes to accept it or not. MacDiarmid continually emphasizes his decentering – and also shrinking – of the human being in the face of the geophysical processes that formed the beach stones throughout the poem. A short way into the piece he offers this advice to his readers:

> We must be humble. We are so easily baffled by appearances
> And do not realize that these stones are one with the stars.
> It makes no difference to them whether they are high or low,
> Mountain peak or ocean floor, palace, or pigsty.
> There are plenty of ruined buildings in the world but no ruined stones.[52]

This unity embodied by the continuous flux that the movements of these stones by the 'assaults of weather and water' poetically discuss and express the shaping and geological structure of the stones, while at the same time embodying the unity of science and poetry. As he writes later in the poem:

> What happens to us
> Is irrelevant to the world's geology
> But what happens to the world's geology
> Is not irrelevant to us.[53]

Through celebration of a deity Pope places humanity as a link in the chain of divine plan. MacDiarmid, however, is unafraid to compare the fragility of the human being in relation to the geological processes of the planet it occupies.

[52] Hugh MacDiarmid, 'On a Raised Beach' from *Selected Poetry*, p.148.
[53] Hugh MacDiarmid, 'On a Raised Beach' from *Selected Poetry*, p.151.

The most important lesson of MacDiarmid's work is that the more we know about the subject, the more material we have with which to write, and the more capable we are of conveying the beauty of that subject/object as it is. As MacDiarmid himself wrote in 'In Memoriam James Joyce':

> The point where science and art can meet,
> for there are two kinds of knowledge,
> knowing about things and knowing things,
> scientific data and aesthetic realization,
> and I seek their perfect fusion in my work.[54]

This was MacDiarmid's hope for his own work, and his hope for the poets that followed him, for the kind of poetry he hoped would emerge when issues between the two disciplines are put aside in favor of an examination of the mutual benefit both stand to gain in the understanding and incorporation of one into the other.

MacDiarmid's conviction that this understanding expanded the poet's ability to appreciate his subject is continued in the poetic works of Edwin Morgan, a contemporary admirer of his work. In the opening lines of his poem 'To Hugh MacDiarmid'[55] he praises MacDiarmid's attempts to enrich his poetry with a deeper and more technical knowledge, to create 'a poetry of facts'. He writes:

> That the poet 'does not number the streaks of the tulip'
> you saw was a fallacy, yet when paradoxical Imlac

[54] Hugh MacDiarmid, taken from Morgan, Edwin, 'Poetry and Virtual Realities', from *Contemporary Poetry and Contemporary Science*, p.33.
[55] Edwin Morgan, *Collected Poems* (Manchester: Carcanet, 1996), pp.153-4.

> claimed that 'to a poet nothing can be useless'
> you concurred, and out of scraps of art and life and knowledge
> you assembled that crackling auroral panorama
> that sits on your Scotland like a curly comb
> or a grinning watergaw thrown to meteorology,
> your bone to the dogs of the ages.[56]

Morgan uses MacDiarmid as both a critique of Samuel Johnson's description of the role of the poet in *Rasselas*, which Johnson describes as:

> To examine, not the individual, but the species; to remark general properties and large appearances: he does not number the streaks of the tulip, or describe the different shades in the verdure of the forest. He is to exhibit in his portraits of nature such prominent and striking features, as recal the original to every mind; and must neglect the minuter discriminations.[57]

Morgan begins his poem by noting MacDiarmid's recognition of the flaw in this perspective, which, as he points out, conflicts with Johnson's later sentiment that the poet 'must know many languages and many sciences'. Morgan's decision to quote Johnson is significant, as the claim that the poet 'does not number the streaks of the tulip' relates to MacDiarmid's own floral reference in 'Poetry and Science'. In praising MacDiarmid, Morgan agrees that, rather than turning from science, poets should embrace it, in doing so, improving their own poetic ability.

MacDiarmid's influence in Morgan's poetry can be seen through his incorporation of MacDiarmid's own method. Morgan's incorporation of scientific

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[56] Edwin Morgan, 'To Hugh MacDiarmid' from *Collected Poems* (Manchester: Carcanet, 1996) pp.153-4.
[57] Samuel Johnson, *The History of Rasselas, Prince of Abissinia* (ed.) D. J. Enright (Harmondsworth: Penguin Books, 1976) pp.61-2.

references is much subtler than MacDiarmid's, and rather than use technical language, he opts to mold the poem around the information concerning the subject. An excellent example of this is the poem 'The Mouth' from his 1979 collection 'Star Gate – Science Fiction Poems'. The piece takes the form of a narrative describing a black hole devouring and growing, referred to in the poem as 'the mouth' or 'the great mouth' from the perspective of an advanced race. The first five stanzas of the poem deal solely with the black hole – 'the mouth' – consuming everything in its path, beginning:

> I saw a great mouth in space that fifty thousand angels could not fill
> they ran shrieking from it as it grew and threw their colored coats
> and flares
> for lures among the stars while it advanced and swallowed the
> planets of the sun
> one by one and then the sun[58]

Rather than use the technical language of astrophysics to describe this encroaching threat, Morgan instead frames the coming black hole with a sense of cosmic horror. Over the next four stanzas the mouth does nothing but consume, and the lack of punctuation in the piece embodies this destruction; the black hole consuming everything as the reader 'consumes' the words of the poem while:

> heavens and paradises popped like seaweed eternal laws were never
> seen again
> angels' teeth were cosmic dust and cosmic dust was angels' teeth all's
> grist
> to that dark mill where christs and godbearers were pulped with
> their domes ikons vanes
> their scrolls aeons and reigns[59]

[58] Edwin Morgan, 'The Mouth', from *Collected Poems*, pp.388-9.

Rather than state facts, Morgan instead shows the reader everything from planets to stars and galaxies falling to 'the mouth'. Even the technological and cultural sophistication of the race belonging to the narrative voice is not enough to stand against a black hole:

> in Virgo they did not underestimate the mouth they were the last
> star-gate and goal
> when they saw no other lights in the recesses of space and
> it was hard
> to distinguish the shadow of the unsated mouth from the shadow of
> the dead
> but its lips were blackest red[60]

Here, the 'blackest red' lips refer to the accretion disc of the black hole, and of the radiation that surrounds its event horizon, 'red' referring both scientifically to the lower energy end of the spectrum of visible light, and poetically to the perceived bloodlust of 'the mouth's hunger. The poem here approaches its end, and yet, rather than a scene of destruction, the poem ends without ending:

> they gaped for Virgo with a scream they gaped for Virgo with a
> scream they gaped for Virgo with a scream they gaped for Virgo
> with a scream they gaped for Virgo with a scream they gaped
> at that great quiet gate[61]

It is a well known phenomena concerning black holes that, to an observer, anything falling into a black hole would not merely disappear into the black hole

[59] Edwin Morgan, 'The Mouth', from *Collected Poems*, pp.388-9.
[60] Edwin Morgan, 'The Mouth', from *Collected Poems*, pp.388-9.
[61] Edwin Morgan, 'The Mouth', from *Collected Poems*, pp.388-9.

but, instead, would appear to be forever frozen in time at the event horizon due to the fact that, past that point, no light from that object/person would be able to reach the observer. Morgan incorporates this into his narrative poem in this final stanza by repeating a single line over and over again as the worlds of Virgo, observing their own destruction, see nothing further than the 'great quiet gate' of 'the mouth' – the event horizon of the black hole. This is an important difference between MacDiarmid and Morgan. As Morgan writes:

> In my poetry in general, I was more interested than MacDiarmid was in the workings of the imagination, and in how scientific facts and discoveries could be opened out fictionally within a broader context of human experience.[62]

While he admires and agrees with MacDiarmid's call for 'a poetry of facts', his work becomes clearer in conveying the science because they do not rely on overtly describing the science. What Lucretius and Morgan do, that isn't as evident in MacDiarmid's work, is to take the science and rework it with poetic imagery that invokes this human experience. This enables the science to become much more accessible to those unfamiliar with the subject.

Perceiving Physical Principles in Digital Poetics

This section will briefly highlight and discuss three significant examples of scientific manifestations in digital poetry: Jim Andrews' *Stir Fry Texts*[63], Serge

[62] Edwin Morgan, 'Poetry and Virtual Realities', from *Contemporary Poetry and Contemporary Science*, p.40.
[63] Jim Andrews, *Stir Fry Texts*, 1999-2000, http://www.vispo.com/StirFryTexts

Bouchardon's *Loss of Grasp*[64], and Brian Kim Stefans' *The Dreamlife of Letters*[65], each of which, though they don't explicitly focus on science, embody key scientific principles through the ways in which they make use of the electronic medium, demonstrating similar forces at work within both scientific research and poetic practice.

Probable Poems

Jim Andrews' *Stir Fry Texts* (beginning in 1999) is an ongoing and collaborative sequence of digital poems characterized by their use of a cut-up central text presented to the reader on the screen, which subsequently rearranges itself whenever the reader moves the curser across the words, producing completely new texts. Andrews himself describes the 'stir fry' itself as a literary form, 'like a sonnet or a madrigal is a literary form' noting that this form 'balks at being your tool,' noting that 'there are so many possible permutations that you can't read them all, never mind plan for them all'.[66] Every different encounter with one of the *Stir Fry Texts* will be a unique encounter, not just to an individual reader, but within each individual encounter of that text by each individual reader. Andrews' texts, at each stage, occur only once, and can only be experienced once. This conforms with C.T. Funkhouser's description of the digital poem, citing Michael Joyce:

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[64] Serge Bouchardon, *Loss of Grasp, 2010*, http://lossofgrasp.com.
[65] Brian Kim Stefans, *The Dreamlife of Letters*, 2000, http://collection.eliterature.org/1/works/stefans_the_dreamlife_of_letters.html
[66] Jim Andrews, 'About the Stir Fry Texts', http://www.vispo.com/StirFryTexts/about.html

> We must remember the absolute rule of electronic text – the elemental key that puts it at odds with printed materials, a discrepancy so perfectly stated by Joyce's axiom, 'Print stays itself, electronic text replaces itself.[67]

In Andrews' *Stir Fry Texts* the text quite literally replaces itself on the screen at the touch of the cursor, replacing itself with itself but never remaining the same 'itself'.

The 'stir fry' bears two similarities to principles in physics, both of which are inherent in its design. The first is in relation to its number of permutations possible with each text. Andrews himself makes this connection in 'About the Stir Fry Texts', using the text 'Blue Hyacinth as his example:

> Blue Hyacinth has 4 passages and each passage is cut into 30 parts. So Blue Hyacinth has 430 texts. This is a very large number. It is about 1, 152, 921, 500, 000, 000, 000. The number is so large my computer can't accurately display a number with that many digits. The number of atoms in the universe is estimated to be about 10^{80}. So were we to make a stir fry with 10 passages, and each passage was cut into 80 pieces, that stir fry would have as many readings as the number of atoms in the universe.[68]

Andrews demonstrates that it is possible to present the reader with a vast number of texts within the boundaries of a localized area. In much the same way as the laws of physics themselves are universal and, as a consequence, operate in every little local area of that universe.

The second important physical principle that can be seen in Andrews' texts is that of quantum probabilities and the effect of observation. Quantum

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[67] C.T. Funkhouser, *New Directions in Digital Poetry* (London: Contunuum, 2012) p.22.
[68] Jim Andrews, 'About the Stir Fry Texts', http://www.vispo.com/StirFryTexts/about.html

mechanics states that subatomic particles exist as superpositions of an infinite number of all probable states until the moment they are observed, at which point that superposition collapses into a single state (this will be covered in greater detail in Chapter 3). Similarly, each of Andrews' *Stir Fry Texts* exists as a superposition of all possible textual states that are collapsed when the reader observes (reads) them. Between each moment when the cursor is stilled, every single possible permutation potentially exists on the screen to which the reader is barred. They may read one 'definite' text, and then read another, but in between contains every possible poem. The conclusion to be drawn from Andrews' work, within the context of physics and digital poetry, is that the multiplicity of each of the *Stir Fry Texts* changes the way we think about the act of reading. As Astrid Ensslin writes in *Literary Gaming*:

> We are no longer talking about texts that are sequentially organized, that offer closure, and that are received largely on a two-dimensional page. Reading is no longer limited to the materiality and format of the codex . . . Literariness in the sense of twenty-first-century verbal art opens itself to an ever-changing array of interactive and multimodal processes. There is no one way of reading digital literature.[69]

This offers a means of dynamically incorporating a high number of different possible texts within a single piece.

[69] Astrid Ensslin, *Literary Gaming* (Cambridge: MIT Press, 2014), p.6.

Code & Control

While Andrews' project explores the transformative possibilities of interactivity, Serge Bouchardon's digital poem *Loss of Grasp* chooses, as its point of departure, that of control versus the illusion of control.[70] Bouchardon's introductory text at the beginning of the piece (presented in four different languages) describes the piece as follows:

> Loss of grasp is a digital creation about the notions of grasp and control. Under which circumstances do we feel we have a grip on our life or not? Six scenes feature a character who is losing grasp. At the same time, this play on grasp and loss of grasp mirrors the reader's experience of an interactive digital [sic][71]

Here the English section of the text on the screen abruptly breaks off mid-sentence. We expect a sense of completion and wholeness to this text, explaining the underlying theme of the poem, based on the most basic rules of written language taught to us as children, which are denied by the text itself as it abruptly cuts itself off mid-sentence.

The first of the six scenes begins with a woman's voice welcoming the reader and instructing them to press the '#' key. Any key may be pressed to continue, though the user will be likely to press that specific key at the request of the voice, giving the user a sense of control while manipulating them. This scene initially gives the reader control over its progression, using mouse clicks to trigger the next line of text, and later allowing the reader to manipulate a series of bright colored circles and chimes, before slowly removing the reader's ability

[70] Serge Bouchardon, *Loss of Grasp* (2010), http://lossofgrasp.com.
[71] Serge Bouchardon, *Loss of Grasp* (2010), http://lossofgrasp.com.

to manipulate anything, first by removing the cursor, then by removing its effectiveness. The piece begins to toy with the user, taking away small amounts of control and causing the user to experience this same doubt regarding their interaction with the text. C.T. Funkhouser, describes the user's predicament aptly when he writes that 'users unavoidably confront their own role in the work: they have only superficially influenced it despite their constant participation.' [72]

The second scene describes a scenario in which a person sees a woman they find 'unbelievably beautiful'. The user is presented with a series of questions and statements that this person could possibly say in this situation, such as 'What do you do for a living?' and 'I like the way you smile.' Below this is the line 'I couldn't say anything coherent.' As the cursor is dragged over one of the lines above text on the screen becomes scrambled into something phonetically similar but semantically nonsensical. For example, 'What do you do for a living?' becomes 'What do you do fall and evening?' Exhausting all of these, the line below changes, stating 'I had to ask questions to reveal her' and, as the cursor is dragged, these questions appear, smeared by the motion of the cursor, superimposing themselves over one another in a frantic, chaotic, and unreadable mass of text that forms a full color photograph of a woman, reflecting the loss of control of ones own words and the inability to take charge of the focus of thought.

The third scene describes the finding of a note whose meaning is unclear: 'Love poem or break up note?' This note is presented as lines of text that move in relation to the cursor. Moving the cursor left or right changes the direction the 'note' is read, and, ultimately, its meaning:

[72] C.T. Funkhouser, *New Directions in Digital Poetry*, p.116.

My love
Has disappeared
Indifference
Is more vivid than ever
The charm of our encounter
Has dissolved
And the slightest misunderstanding
Has vanquished
Our love

Our love
Has vanquished
And the slightest misunderstanding
Has dissolved
The charm of our encounter
Is more vivid than ever
Indifference
Has disappeared
My love

The user is only ever given the conflict between the text's potential to be either a love poem or a breakup note, but neither can be declared to be true or false. The piece forces the user to experience both a love letter and a breakup note, denying the user knowledge of the real intent of the note's author, rendering all of that interaction and participation useless, even humiliating, constantly fluctuating between a sense of controlling (interaction) and a sense of being controlled.

The fourth scene presents a section of a paper written by the son of the narrative voice. This paragraph discusses its writer's disillusionment with the relationship between the title and actions of the 'hero'. Certain words in this will 'explode' when clicked, sending the letters flying across the screen, leaving a hole in the text within which appears a single line of subtext such as 'I don't love you', 'I don't want anything from you', etc. Like the first scene, this deals with one's inability to control one's environment, this time focusing on one's inability to control change and the passing of time.

The fifth scene can be said to give the user the greatest degree of control in the whole piece, owing to the fact that it can be as brief as the user deems necessary. It uses the user's own webcam to present them with an image of themselves, which is warped as the cursor is moved across it, accompanied by a

series of distorted sounds. This focuses on the lack of control we have in relation to our bodies, our appearance, and our image of ourselves. The image of the user becomes greatly distorted and once this distortion has begun it can't be reversed, with any further attempt warping and twisting the image further.

The final scene begins with a single line of text at the bottom of the screen that reads 'Time to take control again'. A command interface appears in the center of the screen, indicating that the user is to type something. Whatever the user types is instantly changed into a fixed of text that reads:

> I'm doing all I can to get a grip on life again.
> I make choices.
> I control my emotions.
> The meaning of things.
> At last I have a grasp.

At this point the piece ends. Here the user is supposedly given the chance to regain control, but only in a way the piece allows. C.T. Funkhouser writes:

> At the end, as the keystrokes briefly register, the user again experiences some control. This coincides with Bouchardon's forceful message: at a few moments of our lives we are in control of or may take power in a given situation; however, a sense of complete control at all times can never be achieved.[73]

However rather than the piece reflecting that we have these brief moments of control (as Funkhouser believes), it would be truer to say that while there may be a brief registration of whichever keys the user types in this final scene,

[73] C.T. Funkhouser, *New Directions in Digital Poetry*, p.120.

ultimately what appears is dictated by the piece itself. Viewed in the context of physics and digital poetry, Bouchardon's piece has an important lesson to offer. The reader/user becomes much more acutely aware that they are not encountering the text on their terms, instead being forced to adhere to the rules of its programming. Similarly the universe itself does not function according to human logic or center itself around human concerns, but adheres to an unchanging set of physical laws that operate over the universe in its entirety. The ludic interface of *Loss of Grasp* offers us a means by which to understand the rules of the digital poem, just as physics offer us the means to understand the laws governing the universe, and in doing so we accept – as does the narrative voice in the final scene of the poem – that we are only permitted a degree of manipulation of the universe determined by its laws, not ours.

Observing Letters

The final piece in this section – Brian Kim Stefans' *The Dreamlife of Letters* – differs from the other two in that it is a non-interactive digital piece, requiring the user to passively observe its progression. As the introductory section of the piece states, *The Dreamlife of Letters* began as a series of concrete poems composed as a result of an online roundtable session on the novelist Dodie Bellamy. One of the responses given impressed Stefans and created the initial idea for the piece. In the introduction he writes:

> I had decided that I wanted to respond to her text in a detailed manner, but I felt that normal prose would not suffice on my part, so I alphabetized the words in her text, and created my own series of very short "concrete" poems based on the chance meeting of words.

Stefans, not satisfied with these short poems, felt that 'Duplessis's text was so loaded to begin with' and that 'it was a sort of antique "concrete" mode'.[74] Stefans took these concrete poems and turned them into a single digital piece within which he could enable the letters and words to become much more visually dynamic.

The Dreamlife of Letters proceeds in sections alphabetically through the words taken by Stefans from DuPlessis' text. In each section these words appear, move, and leave the screen in patterns that seem both random and deliberate. Words and letters appear on screen in different sizes and in different ways: some simply appear, some fall from the top of the window, some spiral and rotate, some drop from other words, some rain down, some are sent flying or otherwise disturbed by the appearance and motion of other words/letters. These words and letters cannot be read in a conventionally meaningful way, but instead appear to perform and act of their own accord, with letters frequently shared between words, words dropping from other words to make new words, words growing into other words, and words being jumbled and rearranged into new and different forms. Aside from the fact that the words/letters in each section begin with the same letter, words and letters that follow each other frequently share another common feature with those into and with which they combine, clash, collide etc. While initially they appear to make no sense, together they mimic visually the way sequences of semantically similar words feel when spoken, seeming to perform on the screen, as C.T. Funkhouser puts it, 'a stunning

[74] These original concrete poems by Stefans can be found here: http://collection.eliterature.org/1/works/stefans_the_dreamlife_of_letters/the_dreamlife_poem.htm

example of how elastic and expressive letters themselves can be'.[75] Each word in the piece is less an individual word and more a conglomeration of letters manifesting themselves as possible words that alternate between other possible words. The 'dreamlife of letters' is the representation of letters left to their own devices, a visualization. The effect of this is, as Funkhouser writes, the 'visually compelling, rapid presentation of asynctactic fragments, keeps readers attentive to the matter of their interconnectivity.'[76] In *Cybertext Poetics*, Marku Eskelinen makes a similar point:

> As lists of words don't bear any trace of their original (or any other) syntax, they completely sever traceable relations to their possible inter- and hypotexts. Such a move also undermines the usefulness of notions of co-presence, imitation and transformation . . . Stefans doesn't merely alphabetize the words of Du Blessis but adds visible behavior to these words, their constituent letters, and their varying sizes, shapes, positions and colors. [77]

Separating words from their original context/syntax, allows them to appear as dynamic and kinetic collections of letters that change and interchange over time.

Digital media enables the letters of Stefans' piece to exhibit behavior. This behavior, when viewed through the lens of physics and poetry, reveals a remarkable similarity to revelations made about the behavior of atomic/subatomic particles. The letters of the piece perform on the screen in such a way that it makes little sense to consider each letter or word as self-contained and discrete. In quantum mechanics, it was likewise revealed that we

[75] C.T. Funkhouser, *New Directions in Digital Poetry,* p.18 and p.235.
[76] C.T. Funkhouser, *New Directions in Digital Poetry,* p.18 and p.235.
[77] Markku Eskelinen, *Cypertext Poetics* (London: Continuum, 2012) pp.60-1.

can no longer consider subatomic particles as the conventional point-particles, as infinitesimally small entities with definite forms and definite locations. Richard Feynman once described it as an electron travelling from point A to point B. In what seems counterintuitive by human reasoning, it turned out that in order to accurately calculate the path that electron took to reach point B, we have to add together the probability of each path that electron could possibly have taken, from the straight line between A and B, to the electron leaving point A, travelling off around the Andromeda galaxy and back to point B. Each possible state has its own probability of occurring, meaning that when it comes to subatomic particles there are no definite states, only states that are more probable than others.[78] Stefans' piece reveals what could be described as the quantum behavior of language itself, the letters and words themselves shifting and changing through a multitude of possible forms as an inherent part of its behavior. His piece, like so many familiar models in physics, is an imaginative approximation of how language *might appear* to behave *if* we could observe it

These three poems each have something different to demonstrate concerning the capacity for poetry to express and embody physical principles. Jim Andrews' *Stir Fry Texts* are based entirely around permutation and probability, in which each poem exists, unobserved (unread), as a multitude of every possible poetic permutation of the source text. Bouchardon's piece *Loss of Grasp* differs from this through its emphasis on explorations of control. In his

[78] Another physicist, John Wheeler, once amusingly speculated (on the phone to Richard Feynman) that the entire universe was composed of just a single electron moving back and forward through time from the beginning to the end of the universe, occupying all of its possible states in between. Oddly enough this theory does actually explain why all electrons have identical properties, making one electron indistinguishable from another.

piece the user is given an illusion of control but is, in fact, controlled by the rules of the piece itself, making explicit the fact that in the act of reading poetry we are inherently governed by certain rules that determine how we read a piece. Stefans' *The Dreamlife of Letters*, in contrast to the preceding examples, moves deeper into more conceptual realms, uniting Andrews' explorations of probability and permutation and Bouchardon's focus on control and rules with language itself, allowing the letters on the screen to behave as we might imagine them to in their natural state which we, the reader, are forbidden to see. These are principles that will not only become apparent in their significance to this present thesis, but, as will be explored in much greater detail in the following chapters, are important because they reveal innate features that can be seen to belong to principles operating within both the language of poetry and within the physical dynamics of the universe itself, testifying not only to poetry's capacity to express physical principles, but also to the common ground they share as disciplines of study.

Chapter 2: Themes of Light

The focus of poems 1-13 is the physical dynamics/properties of light. In much of poetry and art, light is approached in terms of its effects (or the absence thereof), for example the atmospheric effect of a weak stream of light dissipating into shadow in Koninck's painting 'Philosopher with an Open Book', or describing the divine radiance of the fabric of 'the heaven's embroidered cloths' in Yeats' 'He Wishes for the Cloths of Heaven'.[79] Light, here, is primarily a symbolic effect, a representation of 'enlightenment' (or lack thereof); in other words, light defers its meaning to something else. Borrowing from the objectivist perspective, to 'get at the object' and to 'remain "true" to the object without any interference', in approaching light in this way we are pulled away from the atmospheric or emotive effects of light in favor of light itself as a physical concept.[80] We are forced to see light, not in terms of its visual associations (which leads only to the light source) or to the object/subject to which light defers, refers, or represents. By contrast, the aim of poems 1-13 is to see light in terms of its own dynamics, to see the nature of light, rather than the 'culture' of light. In order to attempt a poeticization of light itself, it must be approached as a concept, not as a mere aesthetic effect or a metaphor.

Light, Mass, & Relativity (Poems 1-4)

The most basic approach to injecting a sense of light itself into the concept is, quite simply, to imbue it with an imagined 'voice', to make the concept 'speak'.

[79] W.B. Yeats, 'He Wishes for the Cloths of Heaven', from *W. B. Yeats: Everyman's Poetry* (London: Everyman Paperbacks, 2003), p.15. The line in question is the opening line of the poem: 'Had I the heaven's embroidered cloths'.
[80] Tim Woods, *The Poetics of the Limit* (New York: Palgrave Macmillan, 2002) p.5.

Poem 1, 'Let There Be…', introducing the concept of light, takes the form of a monologue, spoken by the 'Universe' at the moment of the Big Bang, drawing heavily on physical facts. This is an imagined dialogue, written *as if* it were the voice of the Universe applied around the framework of physical understanding (of light), injecting a sense of self, and simulating an anthropomorphised Universe.

The text exists at two 'levels': one grey and the other (the smaller of the two) black and emboldened. Immediately the reader can see that there is a second text embedded within the structure of the first, or the 'overall text'. This technique can be seen in some of John Cage's poems, such as 'Mesostics Re and Not Re Mark Tobey' and 'Writing Through the Cantos', both of which spread capital letters throughout the lines of the poem that spell out the names of abstract expressionist 'Mark Tobey' and modernist/imagist poet 'Ezra Pound' (respectively).[81] It could be said that Cage's intention in doing so was to maintain the emphasis of each figure within the mind of the reader by allowing the name to infiltrate the poem in a manner that is overtly covert. In 'Let There Be…' what is embedded is a series of four equations formulated by Scottish physicist James Clerk Maxwell between 1861/62, which constituted the first true mathematical expression of the behavior of light (electromagnetism). Given that the equation itself uses mathematical symbols, the surrounding text is set to a fainter shade of grey, with the equation text given an additional emboldening, allowing it to firmly stand out against the main body, with each of the four equations determining four of the five stanzas of the piece. The symbols themselves are

[81] John Cage, 'Mesostics Re and Not Re Mark Tobey' and 'Writing Through the Cantos', from *The Norton Anthology of Postmodern American Poetry* (ed.) Paul Hoover (New York: W.W. Norton, 1994) p.18 and p.22.

each incorporated based on their aesthetic resemblance to letters, which, along with the embedding of the equations themselves, creates a poem that can only be fully read as writing, not speech.

The language of the overall piece is formed from a mixture of physical research, poetic imagery, and a conversational tone. The piece begins with the line 'In the Beginning there was' followed by a piece of redacted text. The very nature of redaction, in contrast to *sous rature* is to remove, to delete, and to permanently hide what was beneath, 'was', because from the moment of redaction on it no longer matters what is being/has been redacted, as that information is, from then on, inaccessible. It makes no sense, therefore, to try to define, in any concrete way, what was there before, leaving the reader only able to imagine and interpret the significance of the blackened space. In the case of the early universe, physicist Brian Cox writes:

> When a bomb explodes, it does so at a particular location *in space* and at a particular moment *in time* . . . In the big bang, there is no surrounding space. As we devolve the universe backward toward the beginning, the squeezing together of all material content occurs because *all of space* is shrinking.[82]

The use of redaction in the first stanza signifies that any attempt to write what was there at the beginning of the universe would be meaningless. The redaction is not merely darkness, or blackness, or the absence of light, it is nothingness. It is only *after* this point - the point of the big -bang that the Universe begins speaking. The physics of light are included subtly, as casual conversation. The first stanza describes light as an energy, referring to electromagnetic energy, to

[82] Brian Greene, *The Elegant Universe* (London: Vintage, 2005) p.83.

the fact that light has no mass itself, in which the line 'to oscillate and flux' clearly alludes to its wave-like nature. Much of the poem itself is dedicated to relating these two facts of light – its lack of mass and its wavelike nature – to the word itself, linguistically filling the spaces around the concept with a common and human experience, translating the paradigm of light as a physical concept into the realm of human experience through language and the written form. The speech marks at the beginning and the end of the monologue are emboldened in the same way as the text of the equation, revealing that the Universe is actually just 'saying' the equation, openly displaying its lack of consciousness within *and* around the poem's imagined consciousness. The piece, if the grey text were removed, would read:

'and the Universe said . . .

"$\boldsymbol{\nabla \cdot \mathbf{E} = \rho/\varepsilon_0}$

$\boldsymbol{\nabla \cdot \mathbf{B} =} 0$

$\boldsymbol{\nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial \mathbf{t}}$

$\boldsymbol{\nabla \times \mathbf{B} = \mu_0 J + \mu_0 \varepsilon_0 \partial \mathbf{B}/\partial \mathbf{t}}$"'

Poem 2, 'Racing Light, introduces Einstein's theory of Special Relativity. Maxwell's work seemed to confirm a long held belief that light itself existed as a wave, and all waves - from sound waves to tidal waves - require a medium through which to propagate. In their book on relativity – *Why does E=MC²* – Brian Cox and Jeff Forshaw write:

> The prevailing view at the end of the nineteenth century was that light must travel through a medium, and this medium was known as ether . . . It

> must permeate all of space, since light travels across the voids between the sun and earth and the distant stars and galaxies. [83]

This idea, however, encountered a flaw in the form of an experiment conducted by physicists Albert Michelson and Edward Morley in 1887:

> Michelson and Morley set themselves the challenge of measuring the speed of light at different times of the year. They and everyone else firmly expected that the speed would change over the course of the year . . . because the earth . . . should be constantly changing its speed relative to the ether . . . No difference in the speed of light in any direction and at any time of the year was observed.[84]

This problem would not be solved until 1905, when Albert Einstein produced his 'special theory of relativity', which not only required that the speed of light be constant, but also had no need of the ether. Einstein proposed that the speed of light remains unchanged no matter how fast the observer moves. Whether you move at 1km/h or 100,000km/h, to that observer light will still appear to be travelling at its usual 300,000km/h. The Newtonian view of time, space, and motion, in which those things are fixed, was replaced with a theory that focuses not on the 'things' themselves, but on how they relate to each other. 'Racing Light' concerns Einstein's initial thought experiment – attempting to race a beam of light. The poem takes the form of a series of paths, beginning with a continuous repetition of the word 'Illumination' – the path of a beam of light, instructing the reader – using a typographical arrow – to attempt to race it.

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[83] Brian Cox and Jeff Forshaw, *Why Does E=MC²?* (Cambridge: Da Capo Press, 2010) p.29

[84] Brian Cox and Jeff Forshaw, *Why Does E=MC²?* (Cambridge: Da Capo Press, 2010) pp.30-1.

Running parallel to the textual beam of light is a representation of such an acceleration marked by a sequence of repeated 'gallops' (again, arranged as typographical arrows). The 'gallops' become closer and closer, until they start to overlap, forming an opaque textual 'smear'. This technique, reminiscent of works such as those of Steve McCaffery (such as *Broken Mandala,* and *Vowel Grid Sequence*), enables the writer to create a sense of motion on the page.[85] This first section concludes with a visualization of the path of the reader and the path of the light positioned roughly isometrically, placing the 'position' of the reader directly alongside that of the beam of light within the text of the piece.

Using a reversal of the type of textual smear used in the preceding half of the piece, the second section focuses the fact that it is not the reader whose motion is 'smeared', but the world as viewed from the perspective of the reader, who, conceptually, is now travelling at the speed of light. As the speed of light is constant regardless of the motion of an observer, an observer travelling at the speed of light would notice no difference within their own frame of reference.

Gaps are employed in two ways: firstly as the gap between the observer and the observed, and the gaps between words/phrases. The gaps of perspective invite the reader to locate themselves within the text, to assume the role of the observer, marked by the use of black font, contrasting to the grey font, creating a sense of looking 'across' from one line to the other. In a practical sense, it provides a structural location for the reader to be shown the implications of relativity on his/her perception of time.

[85] Steve McCaffery, 'from Broken Mandala', from *Seven Pages Missing - Volume One: Selected Texts 1969-1999* (Ontario: Coach House Books, 2002) pp.22-7.

The gaps between words serve to perform a reversion of expectation. The larger the gap between words the slower the speed of motion, emphasized through legibility. This is used to emphasize the acceleration of the reader/observer to match the speed of light. However, this to reveals that if the reader/observer did travel at the speed of light, then it is not light that would appear frozen, but the rest of the world around them, as within their frame of reference light continues to travel at its constant 300,000km/s. Though the rest of the world may appear to be frozen in time, in actual fact, relative to the rest of the world light would also be travelling at 300,000km/s, and therefore neither would notice any difference in time in relation to themselves.

Poem 3, 'The Speed of Light', concerns the significance of the speed of light. It involves a physical act of rotation within the act of reading, drawing on poetic works such as Charles Olson's 'My shore, my sounds, my earth . . .' and 'Migration in fact . . .', and Ric Hool's 'River Monnow No. 11, What goes down comes up', all of which involve the reader physically turning the work in order to follow the path of the text. [8687] To begin with, the piece displays Newton's famed equation 'Speed = Distance / Time', in order to emphasize the significance of the finiteness of the speed of light. The first 'section' of the poem toys with its own horizontality. The textual equation is juxtaposed mathematically, creating a split path in which 'Everything is over **Distance'** and 'Everything takes its **Time'** appear as parallel paths, and the text describing 'Light', as in 'Racing Light', uses repetitions of the word whose overlap gradually increases in frequency and

[86] Charles Olson, 'My shore, my sounds, my earth', from *The Maximus Poems* (London: University of California Press, 1983) p.438.
[87] Ric Hool, 'River Minnow No. 11, What goes down comes up' from *no nothing* (Pontypool: The Collective Press, 2009) p.40.

intensity until it becomes unreadable as it spreads across the page, capturing a *sense* of motion, altogether completing a sentence that reads 'even Light . . . has a **Speed** that limits the **Distance** it can cross in **Time**'. At this point the direction of the text suddenly makes a shift, reading upside down, and diagonally across the page in the reverse direction, starting to describe the fact that light, as the means of communicating visual information – of viewing events, of observing, etc. – because of its finite and constant speed, takes time to journey from what is being observed to the observer. Following the initial shift in direction, it shifts again into a tightly curved line that forms the shape of the outline of an eye, immediately followed by an interior ellipse of text that becomes the 'retina', creating the effect of a beam of text travelling into an eye, creating a symbolic relationship between the medium of perspective (light) and the observer, on the page. The shift in direction, the gradual shrinking of text, and the curvature of text, force the reader to physically manipulate the poem as an object, substituting the finite speed of light with a *sense* of a finite speed of reading, causing the effect of taking time for meaning to 'reach' the reader from the piece. By now the general path of the poem has looped back to read, once again, from left to right, in lines laid out diagonally at varying angles in the image of the beam of light travelling *from* the eye, reuniting the reader with the equation from the beginning of the piece, and uniting this with the finite speed of light;

> its telegraphy determined by the path of its
> **Distance**, and thus our reception
> and perception of its **Time**
> and spaces shaped by
> the **Speed** of its source

This effectively places light not only as the medium of the differance, but actually as the differance itself, as the trace. As Derrida writes:

> The trace is not a presence but is rather the simulacrum of a presence that dislocates, displaces, and refers beyond itself. The trace has, properly speaking, no place, for effacement belongs to the very structure of the trace.[88]

Here, Derrida's description of the trace is no different in principle to the role that light –and the speed of light – plays in Einstein's deconstruction of simultaneity in the special theory of relativity.

Poem 4, 'Energy and Mass', concerns the speed limit of light. One question that was not addressed in the previous section was why the speed of light cannot be overcome. The answer is now explored 'Energy and Mass'. The equation $E=MC^2$ concerns the relationship between a body's *mass* and its *energy*. Walter Isaacson cites a postcard from Einstein to a friend (Conrad Habicht), discussing this just before his paper was published:

> One more consequence of the electrodynamics paper has also crossed my mind. Namely, the relativity principle, together with Maxwell's equations, requires that mass be a direct measure of the energy contained in a body. Light carries mass with it.[89]

[88] Jacques Derrida, *Speech and Phenomena* (Evanston: Northwestern University Press, 1973) p.156.
[89] Walter Isaacson, *Einstein – His Life and Universe* (London: Simon and Schuster, 2008) p.138.

What Einstein meant is not that light 'has' mass, but that, as energy is emitted as radiation, the mass of the material would *appear* to decrease, meaning that, as he wrote, 'the mass of a body is a measure of its energy content. Einstein also knew that special relativity required an explanation of the relationship between mass and velocity. Einstein's celebrated equation is presented in the upper right corner of the page. Through each term of the equation runs a vertical line of text, serving to identify each term and explain the literal meaning of the equation. Combined, they read:

> The Energy contained within an object
> Is = [equal] to its
> Mass multiplied by
> 'C' or the speed of light
> Squared (the superscripted ^{2})

The language here follows the same pattern as the opening lines of MacDiarmid's 'Science and Poetry' (see Chapter One), poetically re-presenting a simple statement that describes the meaning of Einstein's equation.[90] Effectively, this forms the first of three 'sections' of the poem, concluded with an enlarged 'therefore' symbol (in red), acting as a bridge to the second 'section' of the piece. This second section of text requires a 90̊ rotation, a physical interaction that shifts the act of reading between the sections. This text begins as a plain line of text, informing the reader that in order for a body to accelerate it requires an increase of energy. As mass and energy are interchangeable, the energy used to accelerate increases the object's kinetic mass. If energy added to the body adds to its mass, it would require more energy to accelerate further. In the text this is

[90] Hugh MacDiarmid, 'Poetry and Science' from *Selected Poetry*, pp.196-7.

shown as the piece describes the increase of the body's mass (as a result of this addition of energy), as the text superimposing itself over itself visually, slightly out of sync on the page, whereby the text remains legible (albeit less so), and also has the appearance of having a sense of motion *and* an increase in mass. The third section of the piece asks the reader to now perform another rotation revealing, emphasizing in red font the three terms of the equation that began the piece, that at the speed of light an object's mass would have become infinite, and as a result an infinite amount of energy would be required to accelerate further, ending with a play on a phrase used by Tolkien in *The Followship of the Rings* - 'You cannot pass!'[91] The emphasis in the scene Tolkien presents is that of light presenting an un-passable limit to that which is not light – the Balrog. In the last line of the poem, the exclamation 'You cannot pass!' is not made by a figure of light but by light itself, or, rather, by the *speed* of light, the fundamental speed limit of the universe.

This piece, as a whole, presents itself as an object that must be manipulated in order to be read. Verticality and horizontality of lines in this piece are used in a very relativistic manner, with lines that are intended to be read horizontally/vertically, and lines that appear vertical, but must be 'made' horizontal through the rotating of the page. Within this, the use of text that superimposes itself over itself in a desynchronized spatial manner, as it did in 'Racing Light', allows the static text to present a sense of something that is in motion simultaneously with a sense of the text increasing in mass.

[91] J. R. R. Tolkien, *The Fellowship of the Ring* (London: HarperCollins, 2008) p.430.

From the Special to the General (Poems 5-8)

Poem 5, 'You Relative to Me (Time)', explores the effects of motion and different frames of reference have on time. The piece is an electronic poem that takes the form of a conceptual train at a conceptual train station, based on an illustration presented by Brian Green in *The Elegant Universe*. He writes:

> A "light clock" . . . consists of two small mirrors mounted on a bracket facing one another, with a single photon of light bouncing back and forth between them . . . "Ticks" on the light clock may be thought of as occurring every time the photon completes a round-trip – a billion ticks means that one second has elapsed . . . Then, all of a sudden, a second light clock slides by on the table, moving at a constant velocity . . . Since, from our perspective, the clock is moving, the photon must travel at an angle . . . The photon bounces off the upper mirror and again travels a diagonal path to hit the lower mirror, and the sliding clock ticks. The simple but essential point is that the double diagonal path that we see the photon take is *longer* than the straight up-and-down path taken by the photon in the stationary clock.[92]

Greene's 'light clock' forms half of the conceptualization used in the poem, replacing Green'es scene with one Einstein used in describing this particular aspect of relativity; a train.

> We suppose a very long train travelling along the rail with the constant velocity c and in the direction indicated. People in this train will with a vantage view the train as a rigid reference-body (coordinate system); they regard all events in reference to the train. Then every event which

[92] Brian Greene, *The Elegant Universe*, p.38.

> takes place along the line also takes place at a particular point of the train.[93]

The piece combines Greene's 'light clock' and Einstein's train to explore, as Brian Greene wrote, 'how motion affects the passage of time'.

There are two locations at the start of the poem: an observer on the platform, and the observer on the train. The former is presented as the position of the reader, who remains stationary observing from the conceptual platform, with the screen acting as both the platform edge across which the reader observes the train, stating that this is the 'concrete precipice of motion; / not yours to cross'. The second position, given a sense of distance through the use of grey shaded text, is occupied by a simplified version of Greene's 'light clock'; the form of a person stood on the train bouncing a ball on the train. The ball takes one second to hit the floor, and one second to return to the hand. This is, as the piece states, a 'train of thought', referring to the fact that the train of the piece is conceptual, and that the piece itself takes the form of a thought experiment. .

The piece then shows the ball moving along a vertical path from the word 'hand' to the word 'floor, and then back again, while the text of the platform describes its motion. Between the two, a third set of text states that each 'bounce' takes one second, displayed in black text, yet positioned on the train portion of the screen-space, acting as a representation the relativity between the two observers. The 'tick'/'tock' of this text also progressively gets larger, to emphasize the constancy of the cycle taken by the ball in relation to its motion.

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[93] Albert Einstein, *Relativity – The Special and the General Theory* (La Vergne: BN Publishing, 2010) p.18.

The conceptual train begins to pull away from the station, and the train text asks the reader to carefully watch the path of the ball relative to their own position. The path of the ball now travels a more diagonal path, the angle of ascent/descent becoming greater, forming an isosceles triangle. The relative text then begs the question 'Is the second still / just that? / Or has time / become a relative matter?' The lines that form the isosceles triangle extend into three squares, bringing the reader to Pythagoras' theorem ($a^2 + b^2 = c^2$), a proof that the hypotenuse of an isosceles triangle is always longer than the other two sides. The ball, from the platform perspective, must have taken longer than a second to reach the floor. The platform is removed from the screen entirely, and the piece displays only that of the train, revealing that, to the person on the train, the ball still falls along a vertical path taking just one second. The only way to reconcile the two perspectives is to accept that the motion of the train causes the stationary observer to see time on the train appear to slow down, whereas time inside the moving train will seem unchanged.

The piece as a whole revolves around the relationship between two spatially separated frames of reference, and it is the relationship between the two from which the meaning of the piece emerges. The principles of Derrida's 'differance' not only apply to the writing of the piece, but also to the physics of relativity being explored. Einstein himself describes the illusion of simultaneity in much the same way Derrida described 'differance':

> Events which are simultaneous with reference to the embankment are not simultaneous with respect to the train, and *vice versa* (relativity of simultaneity). Every reference-body (co-ordinate system) has its own particular time; unless we are told the reference-body to which the

> statement of time refers, there is no meaning in a statement of the time of an event. [94]

Where Derrida discusses meaning emerging from the differance between linguistic elements, Einstein discusses the same principle with regard to time, revealing that perception of time is determined not by the act of observation itself but by the relationship between the observer and the observed.

As an electronic text the piece can both display a relationship between something that is stationary, and something which moves. The electronic text can also create a disparity between the two, a relativity that occurs on screen when one part changes and another remains the same, which, in this case, explores the flaws in a linear (fixed) view of time. As Loss Pequeño Glazier notes:

> Electronic texts provide a subsequent step, projecting writing into charged space, where words themselves extend beyond sequentiality. From context to "dystext," pieces or fragments of the text.[95]

The 'line' in the context of this piece is not the lines of the text, but the linearity of the Newtonian view of time and its replacement with Einsteinian relativistic time. By projecting the writing into the 'charged space' of the electronic form, the reader is able to witness this concrete linear time shift and change in relation to the physical perspective the piece assigns them, in a way that is not entirely dissimilar to the free-running behavior of letters in Brian Kim Stefans' 'The Dreamlife of Letters' and the illusion of control in Serge Bouchardon's 'Loss of Grasp'. Whereas in Stefans piece, letters are allowed to behave as they would if

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[94] Albert Einstein, *Relativity – The Special and the General Theory,* p.19.
[95] Loss Pequeño Glazier, *Digital Poetics: The Making of E-Poetries* (Tuscaloosa: University of Alabama Press, 2002) p.34.

unobserved, here the reader is shown the behavior of light in relation to motion, and its effect on time, both dependent on the observation of the reader, but independent of the reader in terms of a lack of control over physical law (as in Bouchardon's piece).[96] [97] The reader is a part of the piece itself as a textual machine, but that part, though necessary, is little more than that of a passenger on atheconceptual train. The poem itself operates in relativistic time, shifting its own perspective, jumping between the platform and the train, drawing a distinction between the stationary and the mobile, demonstrating that, as 'the real poem extends beyond the line', analogously, time extends beyond passive linearity, being dynamic, and flexible.

Poem 6, 'You Relative to Me (Space)', uses the same visualisation, this time exploring relativistic effects on space. The central image – the train and the platform – is taken from an allegory penned by Brian Greene in *The Elegant Universe*. Using a political scenario, he envisions a solution to a conflict between two warring nations, the presidents of which are to sign a peace accord on a train, doing so with a bulb placed equidistant between them, so that when the light from the bulb reaches both of them at the same time, they sign:

> The president of Forwardland is facing in the direction of the train's motion while the president of Backwardland is facing in the opposite direction . . . Both president's sign the agreement . . . The claim by people from Forwardland is that they have been duped, as their president signed the agreement *before* the president of Backwardland. As everyone on the train – from both sides – agrees that the accord was signed simultaneously, how can it be that the outside observers watching the

[96] Brian Kim Stefans, *The Dreamlife of Letters*, 2000, http://collection.eliterature.org/1/works/stefans_the_dreamlife_of_letters.html
[97] Serge Bouchardon, *Loss of Grasp, 2010*, http://lossofgrasp.com.

> ceremony think otherwise? . . . From the perspective of a person on the platform, the president of Forwardland is heading toward the emitted light while the president of Backwardland is retreating. This means, to the platform observers, that the light beam does not have to travel as far to reach the president of Forwardland.[98]

This piece recreates this scene, removing the political allegaory for simplicity.

It begins with an identical scene to the beginning of 'You Relative to Me (Time)', including the same text used informing the reader of their position. Instead of a figure bouncing a ball, a slim strip of text describes the location of a torch, establishing it as a midway point between observers A and B, both an equal distance from the 'torch text'. The torch is activated, and the reader (on the platform) observes two photons of light moving in opposing directions from 'the torch', emphasizing that the conceptual train is stationary.

The perspective shifts to that of the two observers on the train midway through the poem, showing that there is no change in their perspective; the two textual photons continue to reach both 'A' and 'B' at the same time. With this established, the platform observer/reader is reintroduced, and the text now begins to explore the platform perspective. Shifting back to the moment when the train began to move, the piece now shows the photons moving from the torch to positions 'A' and 'B', however position 'A' begins to move closer to the torch, and the photon travelling there now takes less time to reach it (than to 'B') This reveals another curious aspect of relativity; the apparent contraction of spatial dimensions along the path of motion seen by an observer who is stationary relative to the moving body. This is a phenomenon known as the Lorentz-

[98] Brian Greene, *The Elegant Universe*, p.34-35.

Fitzgerald contraction. In the poem it operates in a way that is reminiscant of Charles Olson's strange mixture of geography and time in 'Maximus to Gloucester, Letter 27 [withheld]', in which the narrative voice, moving through time, equates a relativity between the geography of Gloucester and its people, especially in the lines 'An American / is a complex of occasions, / themselves a geometry / of spatial nature.'[99] Similarly here, as the train moves, the space between the two observers on the train, and the observer on the platform (the reader) warps as the poem progresses. The piece concludes, as did its temporal companion, by returning to the perspective of those on the train and reminding the reader that they notice no difference, travelling at rest relative to the train.

This exploration of the contraction of space is something that writing alone can accomplish. Speech, or poems that are intended to be spoken can't adequatly express an expanding/contracting space. Printed writing too cannot demonstrate this change over time. What is needed here goes beyond writing into 'code', of which Hayles writes:

> In the worldview of code it makes no sense to talk about *signifiers* without *signifieds.* Every voltage change must have a precise meaning in order to affect the behaviour of the machine; without signifieds, code would have no efficacy.[100]

The 'code', as Hayles describes it, is something that is used to cause a change, to perform a function and 'affect the behaviour of the machine'. This allows the text to become kinetic, and to recreate the kinds of phenomena that relativity

[99] Charles Olson 'Maximus to Gloucester, Letter 27 [withheld]' from *The Maxmius Poems*, pp.184-5.
[100] N. Katherine Hayles, *My Mother Was a Computer* (London: University of Chicago Press, 2005) p.47.

describes, as a direct result of its use of both writing and code. Code, in the context of the electronic space, causes a change in the progression of the text in such a way that it makes no sense to apply terms such as 'stanza', 'line number', or 'page', because the text does not appear all at once, and lines of text may appear with such a high degree of non-linearity and convergence. One of the secondary outcomes of these two sister poems is that, alongside exploring relativity in physics, it also demonstrates the relativity of media within the act of writing, or, as Glazier states, 'what writing *is* becomes altered by how it is physically written through its production technology, its files, codes, and URLs.'[101]

Poem 7, 'Light and Gravity', explores Einstein's difficulty with the special theory of relativity was in reconciling its revelations with a theory of gravity. Summarizing Einstein's theoretical predicament, Michio Kaku writes:

> According to Newton, gravity travelled instantaneously through the universe . . . To Newton, the entire universe would witness the disappearance of the Sun instantly, at the same time. But according to special relativity, this is impossible, since the disappearance of a star was limited by the speed of light. According to relativity, the sudden disappearance of the Sun should set off a spherical shock wave of gravity that spreads outwards at the speed of light. Outside the shock wave, observers would say that the Sun is still shining, since gravity had not had the time to reach them. But inside the wave, an observer would say that the Sun has disappeared.[102]

[101] Loss Pequeño Glazier*Digital Poetics,* p.4.
[102] Michio Kaku, *Parallel Worlds*, (London: Penguin Books, 2005) p.34.

'Light and Gravity' explores the incompatibility of Newton's and Einstein's theories using the concept of the sentence. The piece consists of a series of lines that treat the written words of a sentence as a linear bond between the start – the capital letter – and the end – the full stop. The capital that begins each line is enlarged and colored yellow, representing the Sun, and the full stop – colored blue – becomes the Earth, with the text between acting as the gravitational attraction that holds together the sentence from start to end.

The poem is divided into two sections: the Newtonian section, marked by a capital 'N' and a capital 'E' (both as the sun), following a similar style to Charles Bernstein's 'War Stories', which consists of a collection of single line statements.[103] Between the Newtonian sections the reader will find the 'refrain' '*(but light is finite)*', in which the 'but' indicates a problem with the perspective. During the Einsteinian section, however, the 'but' is replaced with 'because' – '*(because light is finite)*' – indicative of a solution.

The first section – Newtonian – consists of three lines, the last of which is visible to the reader only faintly, The first two lines describe Newton's view of gravity as a the tether of a sentence that binds the 'Sun' (the 'N') to the 'Earth' (the full stop), and that the removal of the sun, according to Newton's 'sentence', is felt straight away by the full stop, shown on the page by the full stop's now drifted position (further from the translucent 'N'). The third 'sentence appears faintly, barely visible, allowing the reader an explanation of the effects of such a disappearance within the context of Newton's theory, while not requiring that the text be completely absent from the page.

[103] Charles Bernstein, 'War Stories' from *All the Whiskey in Heaven* (New York: Farrar, Straus and Giroux, 2010) pp.283-290.

Moving onto the Einsteinian section, the text recognizes that reading is not an instantaneous act, but one of progression, from letter to letter within words, and from word to word in a sentence. Here, the speed of light is once again replaced with the 'speed of reading'. In this section, rather than a sudden disappearance, the last line shown slowly breaking away progressively from the beginning of the, reaching the end of the sentence (the full stop) at which point it begin its drift away.

Here the presentation of the Newtonian and Einsteinian perspectives on gravity next to each other on the page allow the reader to compare the two sections, while the sequential juxtaposition of the two sections display the progression from the Newtonian to the Einsteinian. As in Veronica Forrest-Thomson's poem 'Address to the Reader', in which she writes 'Transformational Grammar / "peoples" the "emotional landscape"', here written language is being used as a substitute for aspects of the physical theory, while also drawing a parallel between that which is described by the theory and the way written language 'behaves' within the act of reading.[104] This piece makes no attempt to interpret the theory of relativity, but instead attempt to apply the physical theories through poetic construction.

Poem 8, 'Freefall – The Happiest Thought', explores Einstein's eventual solution to the conflict between his and Newton's theory of gravitation. As Walter Isaacson writes in his biography of Einstein, this fascination revealed much about the way Einstein's mind worked:

[104] Veronica Forrest-Thomson, 'Address to the Reader', from *Collected Poems* (Exeter: Shearsman Books, 2008) p.116.

> He was eager to generalize theories rather than settling for having them restricted to a special case. There should not, he felt, be one set of principles for the special case of constant-velocity motion and a different set for all other types of motion. His life was a constant quest for unifying theories.[105]

The solution lay in a fundamental difference between Newton and Einstein's theory; namely, that Newton didn't define what gravity actually is. The answer occurred to him suddenly as he contemplated the problem:

> "I was sitting in a chair in the patent office at Bern when all of a sudden a thought occurred to me," he recalled. "If a person falls freely, he will not feel his own weight." That realization, which "startled" him, launched him on an arduous eight-year effort to generalize his special theory of relativity and "impelled me toward a theory of gravitation." Later, he would grandly call it "the happiest thought in my life."[106]

Incorporating this idea with his special theory of relativity, and with his equation regarding the equivalence of mass and energy ($E=MC^2$), Einstein soon discovered that what we feel as gravity itself was a product of mass. In summarizing Einstein's solution, Michio Kaku, in his book *Hyperspace*, uses an analogy of mathematician Georg Bernhard Riemann, which features hypothetical 'bookworms' living on a two dimensional piece of paper:

> Put these bookworms on a *crumpled* sheet of paper. What would these bookworms think about their world? Riemann realized that they would conclude their world was perfectly flat. Because their bodies would also be crumpled, these bookworms would never notice that their world is

[105] Walter Isaacson, *Einstein – His Life and Universe*, p.148.
[106] Walter Isaacson, *Einstein – His Life and Universe*, p.145.

> distorted. However, Riemann argued that if these bookworms tried to move across the sheet of paper they would feel a mysterious, unseen "force" that prevented them from moving in a straight line.[107]

The presence of mass warps the fabric of space-time towards the center of that mass, and the intensity of the warping is proportional to the density of matter within that mass. Gravity, as the warping of Einstein's space-time, is felt as a body, attempting to move in a straight line through space, moves towards the center of a mass because the space *itself* is curved towards this center. The closer to the center of the mass the body gets, the more space-time is warped, and the body accelerates until, for example in the case of a falling person, they encounters the surface of the Earth, preventing further motion, and causing the person's body to offer resistance to gravity, prompting Einstein to note that, in that initial state of free-fall, the person will not feel their own weight because their body is not resisting gravity.

Drawing on the visual style of Rémy Peignot's typographical piece 'Univers', the poem is divided into two parts on the page, each offering a different perspective on the same scenario: a body falling into a gravitational field.[108] The right hand section of the page offers a 'profile' view, and the left hand side offers a 'plan' view, forming a cross section of the same image. At the innermost point is the center of mass – marked by a dot, around which there is a blue circle marking the Earth. Emanating from this is the repeated line 'all space warped to', which is

[107] Michio Kaku, *Hyperspace* (New York: Oxford University Press, 1999) p.36.
[108] Rémy Peignot, 'Univers', from *Typoésie*, (ed.) Jérôme Peignot, (Paris: Imprimerie nationale Editions, 2005), p.95. Peignot's piece depicts a swirling accretion composed entirely of the letter 'U', rotating about a common center, with weaker and smaller text forming arms trailing out around the edges, and denser, larger text nearer the center.

warped - the line curved on the right hand side, and the letters compressed on the left – which creates a textual gravitational field on the page, marked by sentences whose full stop is the dot at the center of the blue circle. On either side of the dividing line are repetitions (with slight variations) of the same stanza. On the right hand side we can see that, initially these stanzas seem to 'move' in a straight line across the page until they begin to encounter the 'gravitational field'. At this point they begin to turn, and to follow a curved path that brings their path to the edge of the blue circle, and as they do the words themselves become 'heavier', letters first being emboldened, then having the spaces between the lines and between the letters themselves gradually reduced until, at the 'surface', they become compressed by their resistance to motion; the text, at this point, 'feels its own weight'. On the left hand side we see the same transformation of the same text, shown as that text following the same text, viewed as moving 'away' from the reader and down towards the blue circle; the same curve seen 'head on'. Throughout both, the stanza that is repeated varies several times in its second line, with the words 'do not' first being replaced by 'start to', then 'do', and then finally the sentence just continuing to the next line, making a transition from:

'these words do not / feel their own weight'

to

'these words start to / feel their own weight'

to

'these words do / feel their own weight'

and finally to

'these words / feel their own weight'

mirroring the change in both the language of the piece and in its visualization. This is similar to Veronica Forrest Thomson's use of subtle variation in the first section of her 'Variations From Sappho'.[109] Just as the lines of her piece alter by incremental degrees from line to line, resulting in a first and last line that bear little similarity, so here does the language of the stanzas subtly shift conceptually from 'weightlessness' to 'having weight'.

Using two different perspectives presented as a cross section, the piece, creates a *sense of* three dimensionality, using a two dimensional surface to demonstrate the effects in higher dimensions, not unlike the way Edwin Abbott used a world of two dimensional shapes experiencing a third in his novel *Flatland.*[110] Three dimensional warping of space itself is difficult to visualize, and by making use of two dimensional media, the effort is simplified by the fact that the piece does not try to *replicate* three dimensions but to *represent* them. In doing so, once again, it treats the page as a 'space of poeisis' (to use Loss Pequeño Glazier's phrasing), as an active part of the text, within the boundaries of which the text can explore.

At the heart of the piece itself - both in terms of its subject and its meaning - is relativity, of the relationship between the visuo-textual elements on the page. As physicist Lee Smolin notes:

> Space is nothing apart from the things that exist; it is only an aspect of the relationships that hold between things. Space, then, is something like a

[109] Veronica Forrest-Thomson, 'Variations from Sappho', from *Collected Poems*, p.68.

[110] Edwin Abbott, *Flatland* (New York: Cambridge University Press, 2010). As it wouldn't be possible for a three-dimensional being (Abbott's readers) to comprehend four spatial dimensions, they can comprehend two, and, therefore, a two dimensional being encountering three.

> sentence. It is absurd to talk of a sentence with no words in it . . . The geometry of a universe is very like the grammatical structure of a sentence. Just as a sentence has no structure and no existence apart from the relationships between the words, space has no existence apart from the relationships that hold between things in the universe. [111]

Where the geometry of the text changes, so too does the path of the 'falling' text, and though to 'it' the path would seem straight, to the reader, existing in a third dimension beyond the two dimensional text, can see the curve caused by the curving of the space it follows and moves through.

Light in the Universe (Poems 9-13)

Poem 9, 'The Doppler Effect', concerns the eponymous theory named after Christian Doppler in 1842, is, as astrophysicist Neil DeGrasse Tyson states:

> The change in frequency of a wave being emitted by an object in motion. One can think of the moving object as stretching the waves behind it (reducing their frequency) and compressing the waves in front of it (increasing their frequency). The faster an object moves, the more the light is compressed in front of it and stretched behind it.[112]

An object that is moving away from the observer seems to stretch the light wave emitted behind it, lowering its frequency into the red spectrum – known as 'red shifting' – and an object moving towards the observer increases its frequency

[111] Lee Smolin, *Three Roads to Quantum* Gravity (New York: Basic Books, 2001) p.18.
[112] Neil DeGrasse Tyson, *Death by Black Hole and Other Cosmic Quandaries* (New York: Norton, 2007) p.147.

into the blue spectrum – known as 'blue shifting[113]'. In astrophysics this is used to determine the position and motion of objects in space, particularly stars and galaxies. 'The Doppler Effect' uses the concepts of red shift and blue shift to construct a diagram in the form of the Doppler Effect itself, in which two texts, juxtaposed side by side, are red and blue shifted on the page, written as waves of writing that on one side become stretched from the point of origin and on the other compressed. The text itself supplements the diagram by describing it in terms of a structured experience that forms a human reflection of its non-human concept, following a similar structure to Mary Ellen Solt's audio-visual poem 'Zigzag', in which the piece is both presented visually and spoken, consisting of a series of 'z's and pauses that, on the page, appear as a zigzag, and which form the word 'zigzag' periodically. Sound, in this piece, is used in a similar way to the wavelike zigzag of the performance aspect of Solt's piece, but in a much more conceptual way, within the writing of the piece itself rather than as part of its intended performance.[114]

The first column/wave describes the 'voice' of someone falling or drifting away from the observer, crying out to the observer, gradually fading away, losing energy as they do so. It begins with chains of words inhabiting each line that then break down into pairs of words, to single words, before the words themselves break down into individual letters. This forces the reader to gradually slow down, having to connect phrases, then words, parts of words, and letters, simulating the loss of energy observed in red shifted light emitted from an object

[113] Shifting, in this context, refers to the 'shift', or increase/decrease, of wavelength.
[114] Mary Ellen Solt, 'Zigzag', from *Text-Sound Texts*, (ed.) Richard Kostelanetz (New York: Morrow Quill, 1980), p.58.

that is moving away. The second column – the blue shift – describes the scene of a busy Metro station (drawing from the image presented by Ezra Pound in his famed imagist piece), with someone being pushed towards the reader (observer) by the crowd itself, becoming increasingly frantic.[115] In contrast to the other column, this section gains energy, beginning as fragments of words that become full words, phrases, and eventually full sentences compressed on the page as the subject of the text becomes more and more panicked.

What truly conveys the concept is the form of the diagram, the expanding/compressing waves on the page, and the fact that the red shifted section literally becomes redder, and the blue shifted section becomes bluer. The reader can see this even before reading the text. The text itself acts as a guide to the diagram, present to ensure that the context of the piece is clear. In a similar way to Edwin Morgan's treatment of a black hole in 'The Mouth' (see Chapter One), the concept is translated into a human experience through the text, and into a diagram through the form, at which point the two are combined, working synchronously to ensure that the concept remains as intact as possible in their conveyance from their source language to their target text.[116]

Poem 10, 'How to Travel Faster than the Speed of Light' explores a consequence of relativity's view of space. Though Einstein's theories revealed that travelling faster than the speed of light would violate the laws of physics, it paradoxically inherently includes a means of travelling distances *as if* one had travelled faster than the speed of light. In Edwin Abbot's novel *Flatland* (set in a two dimensional universe), the novel's narrator observes another character – a

[115] Ezra Pound, 'In a Station of the Metro' from *Personnae: The Shorter Poems of Ezra Pound* (New York: New Directions Books, 1990) p.111.
[116] Edwin Morgan, 'The Mouth', from *Collected Poems*, pp.388-9.

sphere - (which he sees as the edge of a circle that fluctuates in size) disappear and reappear in a different location.[117] The sphere had done this by moving into the third dimension (depth) and then returning, passing *through* the plane-world of Flatland. Seeing as the narrator's eyes are two-dimensional, he can only see light in two dimensions, so as soon as the sphere left the plane it became unobservable. There would, however, be a way that A. Square could have performed a similar feet: if the 2D space-time of Flatland could be bent so that two points (origin and destination) were touching, A. Square could theoretically leap from one point to another. To observing Flatlanders he would seem to have disappeared and then reappeared. He would have travelled through what is commonly referred to as a 'wormhole' (an Einstein-Rosen Bridge). If the distance between those two points were great enough – e.g. one light year – then in having travelled from A to B in a brief moment, A. Square would have *seemed* to have travelled faster than the speed of light.

Exploring this, the poem gives the reader a single instruction; read from '**here**' to '**here**'. Between the two points is a line of text describing a straight path from one to the other. The language, however, tells the reader how to 'cheat'; physically bend the page so that the lines 'Read from here' and 'to here' become adjacent, cutting down the distance across the page the reader must traverse and, therefore, the amount of time it takes to read the piece. By bending the sheet of paper, the reader eliminates the need for the longer line of text, completes the piece quickly, and within this poetic universe, 'seems' to travel faster than the speed of light, embodied by the speed of reading. The piece offers two physical routes through the text; the long way and the shortcut. It is between the two,

[117] Edwin Abbott, *Flatland* (New York: Cambridge University Press, 2010).

however, that the translation of the subject's paradigm is hidden. In order for it to become apparent, the reader must actively interact with the text as an object, manipulating it by bending it. The fact that the text itself signposts the shortcut along the longer path causes the language to interact with the medium of the poem, and through the act of being read, influence the manipulation of the poem's 'universe'.

Poem 11, 'Double Slit: Part One' concerns light viewed as a wave. Light has been as a wave, though debated for several centuries, seemed to have been confirmed in an experiment performed by Thomas Young in 1801. The experiment itself is known as the 'Double Slit Experiment', and is described by Marcus Chown early on in *Quantum Theory Cannot Hurt You* as follows:

> English physician Thomas Young . . . took an opaque screen, made two vertical slits in it very close together, and shone light of a single color onto them . . . A characteristic property exhibited by waves is interference. When two similar waves pass through each other, they reinforce each other where the crest of one wave coincides with the crest of another, and cancel each other out where the crest of one coincides with the trough the other . . . In the path of the light emerging from his two slits Young interposed a second white screen. He immediately saw a series of alternating dark and light vertical stripes, much like the lines on a supermarket bar code. This interference pattern was irrefutable evidence that light was a wave. [118]

'Double Slit: Part One' recreates this experiment as an electronic poem, translating the scene of Young's experiment into a dramatic love story between the experimenter and the beam of light.

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[118] Marcus Chown, *Quantum Theory Cannot Hurt You* (London: Faber and Faber, 2007) pp.17-8.

As an electronic piece, the concept – a moving beam of light – is recreated visually, structuring the text as a wave that appeared in sections with each click of the mouse, allowing the beam of light to progress across the screen. As each new section appears, the preceding sections are become grey, fading to a background level while remaining visible as the traces of the linguistic light wave. As a continuous wave, the text itself contains no punctuation to ensure that the 'voice' of the text as written is both visually and verbally uninterrupted. The text continues as a single wave until it encounters its on-screen barrier, at which point it is split into two separate waves. Initially they run parallel, and as such contain no differences in language at all. This synchronicity soon begins to fail, and as the two waves start to de-cohere visually on the screen, their wording, while still both describing the same things, gradually becomes different. When the waves are in sync, when the light would be amplified, the text remains easy to read, but when they 'interfere' with each other, at the points light would be cancelled out, it becomes difficult, both because the texts constantly cross over one another, and because the reader is forced to read two separate (and different) lines at once. The voice of the poem – what the words themselves are saying – has been split into two conflicting voices speaking at the same time, not unlike the poems in Ira Lightman's collection *Duetcetera*.[119] This works with the visual structure of the experience – the wave-text lacking hindering punctuation – to convey the concept of interference, leading to the end of the piece, the screen that displays 'Light is a wave' in light and dark stripes,

[119] Ira Lightman, *Duetcetera* (Exeter: Shearsman Books, 2008). Lightman's poems in this collection are presented in two or three separate columns, giving the reader(s) the decision as to whether they should be read separately (and sequentially), as a single poem, or both at the same time (interfering with one another).

signifying the end of the experimenter's pursuit through the trial of romance, to the answer – the knowledge – that has finally been discovered. The physics has been conveyed through an experience structured by the voice of the text – which is a translation itself of the concept into a love story – and through the visual structure created by the text on the screen and the use of the electronic medium to enable it to change over time.

Poem 12, 'A Light Staccato', introduces a different view of light. The double slit experiment seemed to confirm that light was a wave, however the wave view came under scrutiny a century later through the work of Max Planck and Albert Einstein. In Max Planck in 1900 published his work on 'black body radiation', in which he discovered that when a black body (an object that absorbs light across all spectrums but reflects none) is heated, the wave view of light would mean that the energy of the radiation emitted would continue to increase exponentially, meaning that people sitting near open fires should experience extreme physical damage from high levels of electromagnetic radiation. This is, obviously, not the case. Planck realized that if the emitted radiation was treated as discrete quanta then the levels of the emitted radiation would fall mostly within the mid-range. He believed, however, that this was purely a mathematical convenience. It was only in 1905 that Albert Einstein realized that if light were actually a particle in reality, it would solve the mystery of the 'photoelectric effect'. This occurs when a piece of metal is exposed to light in the blue spectrum (or higher) and an electrical current was produced. If light were a wave, then it would merely pass through the material or be reflected. By taking Planck's research one step further, claiming light *actually* existed as particles, it would be as if a stream of bullets were striking the material, energizing and dislodging

loose electrons and causing them to move throughout the atomic lattice. This, was proven to be correct, and is the subject of the next piece, 'A Light Staccato'.

A useful illustration of this shift is musical notation. A piece of music cannot be constructed without discrete units: notes. Something continuous – a wave on a page – would not give the musician any indication of how to play a piece. Instead, much like language, music is fragmented into basic units that are then chained to form hierarchical relationships, adding meaning at each level. As Barthes says:

> A phoneme, though perfectly describable, means nothing in itself: it participates in meaning only when integrated in a word, and the word in turn must be integrated in a sentence.[120]

Which can be rewritten here as:

> A *note*, though perfectly describable, means nothing in itself: it participates in *music* only when integrated in a *bar*, and the *bar* in turn must be integrated into a *line*.

Drawing from works such as the written form of Charles Dodge's 'Speech Songs', in which poems by Mark Strand are translated into musical notion, the piece of music, in this piece, becomes the electric current of the photoelectric effect, and the staves become the strip of metal.[121] The blue light, shone upon the strip of metal (the staves), is the act of reading itself; the interaction between the reader and the poem as a piece of writing,. The first two staves represent the view of

[120] Roland Barthes, 'Structural Analysis of Narrative', from *Image Music, Text* (London: Fontanna Press, 1977) p.86.
[121] Charles Dodge, 'Speech Songs', from *Text-Sound Texts*, (ed.) Richard Kostelanetz, p.362.

light as a wave within the context of the photoelectric effect, with a line of text describing the inadequacy of the perspective beneath each. On the stave itself is a blue wave-like line, continuous from end to end; this makes no sense as music. The text further emphasizes this with the use of *sous rature*, openly exhibiting to the reader both its content and the fact that its content is incorrect, a mistake that has been struck out. The second two staves go on to describe how, with the particulate view of light, the photoelectric effect becomes explainable. Here, the wave has vanished, and each instance of the letter of a musical note (the letters a-g) has been removed from the line of text and placed above on an appropriate space on the stave. The piece of music now makes sense.

This presence of the staves, the wave-like line, the *sous rature*, and the shifted sections of letters all work together as components within the textual machine visually, capable of being 'read' but not 'spoken'. This might best be described as 'graphemechanical', after the 'grapheme', the smallest unit of written language (of writing, the visual), and the mechanical operations caused by code (in response to that visuality).[122]

Poem 13, 'Double Slit: Part Two', explores the double slit experiment in light of Einstein's revelation. In proving that light was a particle, Einstein's work posed another problem; it did not explain the interference pattern that appeared in Young's experiment. How would a beam of low intensity light – so low it fires just one photon at a time – produce the interference pattern? A single particle of light must pass through one slit or the other, in which case there should not be an interference pattern appearing, as the light would not be split, thus

[122] In deriving the term 'graphemechanical' I decided not to hyphenate the two words, instead, allowing the last two letters of 'grapheme' and the first two letters of 'mechanical' to overlap and be shared by both.

preventing it from interfering with itself. 'Double Slit: Part Two' is designed specifically to pose this question.

The piece itself appears similar to 'Double Slit: Part One'. Once the poem proper begins, however, the focus on the particle becomes apparent through the use of both self contained stanzas that are individual haikus, creating a graphemechanical beam of light composed of individual poetic photons. As a new stanza appears at the click of a mouse, it rewrites the context of the information that preceded it in the same way that new scientific evidence – such as Einstein's work on the photoelectric effect – rewrites the context of evidence that has gone before it. Whereas in 'Double Slit: Part One' previous 'wave segments' remained visible, here, once a new stanza appears, its predecessor is removed, emphasizing the discreteness of the particle, drawing on the final section of Bouchardon's 'Loss of Grasp', in which the reader is invited to type whatever they want into a text box, with whatever they type subsequently rewritten by the piece.[123] Here, the piece is continually rewriting itself, which the reader (as experimenter) observes. The stanzas exhibit a temporal impermanence, seeming to appear forever in the present moment, while spatially there is always writing on the screen The reader is given the information in schemas, but is expected to connect them his/herself, the progressive nature of which triggers the coded operation of the 'click', which delivers yet another packet of information.

The reader performs a graphemechanical re-enactment of the experiment in order to pursue the answer, the solution. However, this never occurs within the piece. As the piece reaches the double-slit screen, it jumps to the screen (and the interference pattern, which employs *sous rature* with each appearance of the

[123] Serge Bouchardon, *Loss of Grasp, 2010*, http://lossofgrasp.com.

word ‘wave’) at the end of the apparatus, moving back towards the double-slit. No answer is given (at least in this piece). The end of the piece takes place between the two slits, displaying only the word ‘question’ and a question mark. This serves to bring about the realization that the piece would never lead the reader to a solution – in the same way that the physical experiment (initially, at least) didn’t reveal the answer to the particle puzzle – but, instead, aimed to draw the reader’s attention solely to the question being posed, to emphasize its subtle, yet great significance, reflecting – through the reader – the same confusion and crisis of conventional logic that was experienced at the dawn of the 20th century, marking the start of the quantum revolution.

Chapter 3: Themes of Probability and Uncertainty

The Subatomic Universe

The interference pattern that emerged in the double slit experiment demonstrated behavior typical of a wave, whereas a wave would not be able to explain the photoelectric effect. On one hand the particle is 'discrete', and on the other the wave is continuous. How can something exhibit both discrete and continuous properties, and how can we conceive of something that is both discrete and continuous? In order to answer these questions it is necessary to detour through the physics of the atomic/subatomic.

To human eyes things appear either discrete or continuous: a stone is a discrete 'thing', a length of cable is continuous. When dealing with the something so seemingly abstracted from human experience, it is necessary to form approximations of an ideal form that partially emerges in reality as an imperfect/incomplete specter of itself, in the same way as Plato's ideal mathematical forms as described by Roger Penrose:

> Mathematical propositions . . . referred not to actual physical objects . . . but to certain idealized entities. Physical structures, such as squares, circles, or triangles cut from papyrus, or marked on a flat surface, or perhaps cubes, tetrahedral, or spheres carved from marble, might conform to those ideals very closely, but only approximately.[124]

With this in mind, there is one concept that is very often encountered in its practical manifestation, in which we may find exhibited an approximation of the simultaneity of the discrete and the continuous: language itself.

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[124] Roger Penrose, *The Road to Reality* (London: Vintage, 2005) p.11.

Introducing Atoms (Poems 14 and 15)

Poem 14, 'The Size of Little Things', introduces an approach to the universe at its most minute scale, clarifying just what that scale is in relation to the everyday world. This poem has its roots in a quote from Marcus Chown's book *Quantum Theory Cannot Hurt You*:

> It would take 10 million atoms laid end to end to span the width of a single full stop on this page.[125]

This statement is effective because of its brevity and its use of the familiar to explain what is unfamiliar. Chown selected a familiar corollary (the full stop), gave a swift numerical comparison of size, and ended the sentence. Any further description would dilute the comparison and place greater distance between the subject and its description. In any illustration of something that is extremely small, the illustration itself should be as small as possible, keeping the psycho-visual gap between the two as minimal as possible. The linguistic illustration behaves in the manner of Barthes' *functions* and *indices*, which he describes thus; 'the former correspond[s] to a functionality of doing, the latter to a functionality of being'.[126] The sentence is describing (doing) the size of the atom, while 'being' the smallest possible sentence that allows adequate conveyance of the point being made.

Any attempt to expand on, or extend Chown's statement would dilute its effect. The problem is similar to the way Ezra Pound viewed symbolism:

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[125] Marcus Chown, *Quantum Theory Cannot Hurt You*, p.4.
[126] Roland Barthes, 'Structural Analysis of Narrative', from *Image, Music,* Text, p.93.

> I believe that the proper and perfect symbol is the natural object, that if a man use 'symbols' he must so use them that their symbolic function does not obtrude; so that *a* sense, and the poetic quality of the passage, is not lost to those who do not understand the symbol, to whom, for instance, a hawk is a hawk.[127]

To attempt to replicate the size of an atom on the page would result in an apparently blank piece of paper. Chown's image, however, gives the atom a vehicle, something that is visible and visually recognizable; to paraphrase Pound, 'a full stop is a full stop'.

This poem can be considered as two 'texts'. The first is merely the full stop at the start of the piece that acts as its own *function* and *indice*: it is what it is, and it communicates both the end and the beginning of a sentence.[128] The second 'text' becomes a 'metapoem', a poem about the first poem. It expands on Chown's statement by ironically drawing attention to the inability of language to capture the scale of this particular subject, defining the perimeter of the subject. Instead of making the size of the atom the absolute focus of the piece, it is the inconceivability of its size that is emphasized, putting the first poem in context, and in turn puts the atom.

The piece ends with the full stop of the metapoem's final line dropped to the line below, performing a poetic *ritornellos*, inviting the reader to look at the

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[127] Ezra Pound, 'A Retrospect' from *The Literary Essays of Ezra Pound* (New York: Penguin Books, 1968) p.9.

[128] The capital letter can appear anywhere mid sentence, and can signify several things, whereas the full-stop, in marking the end of one sentence, also, therefore, marks the beginning of another.

full stop again equipped with the information contained in the metapoem.[129] The full stop, therefore, frames the poem in terms of its form, and acts as a before-knowledge/after-knowledge time-lapse metaphor of the shift in signification of this common signifier.

Poem 15, 'H', expands on the previous poem by focusing on the empty space that makes up 99.9999999999999% of the atom's volume. A useful illustration of this can be found in Tom Stoppard's play *Hapgood*. He writes:

> Now make a fist, and if your fist is as big as the nucleus of an atom then the atom is as big as St. Paul's [cathedral], and if it happens to be a hydrogen atom then it has a single electron flitting about like a moth in an empty cathedral, now by the dome, now by the altar.[130]

Stoppard translates the paradigm of the atom's emptiness into a concrete image, a sense of place that is transposed and reconfigured into the form and structure of this poem. This electronic piece reconstructs the passage in a minimalist fashion. The first line of text that appears simply states that the reader is in St. Paul's cathedral. The 'fist' appears and is situated within the 'empty' cathedral, halfway down the aisle. Whereas Stoppard's passage identifies only two points, the piece includes four, introducing the north and south transepts, to produce a stronger impression of a circular orbit through which the text 'leaps', mimicking the flitting motion of a moth around the fist.

After a couple of introductory orbits the text begins to change. The word 'moth', for a fraction of a second is replaced with the word 'electron', while the

[129] *Ritornellos* is a musical term meaning 'little return', used to describe a section of a piece of music that occurs more than once, that 'returns'.
[130] As quoted in Marcus Chown's *Quantum Theory Cannot Hurt You*, p.12.

text of the fist becomes replaced by 'proton'. The four points also become replaced with two words that alternate; 'nucleus' and 'orbit'. This effect slowly becomes much more pronounced, eventually overriding the original text entirely in a transition over length of the poem. Throughout, there in the background, is the emptiness, the void between fist and moth, proton and electron. In gradually transforming one image into another, the effect is transferred as a property of both, and the reader touches the edges of this space marked by the solidity of the single proton, and the motion described by the electron. This piece is, essentially, an inverse of Charles Bernstein's 'This Poem Intentionally Left Blank', focusing not on a presence within an intended absence, but an absence within a presumed presence.[131]

Four Fundamental Forces (Poems 16-19)

Everything in nature is made possible by four fundamental forces: electromagnetism, gravity, and the strong and weak nuclear forces. These four forces govern all interactions and are responsible for all physical phenomena, operating at the subatomic – the *quantum* – scale. Each is mediated by its own force particle, and in *The Elegant Universe* Brian Greene provides a simple chart that identifies each force, along with its corresponding particle (and the particle's mass) in order of strength:[132]

[131] Charles Bernstein, 'This Poem Intentionally Left Blank', from *All the Whisky in Heaven*, p.245.
[132] Brian Greene, *The Elegant Universe*, p.11.

Force	***Force Particle***	***Mass***
Strong Interaction	Gluon	0
Electromagnetism	Photon	0
Weak Interaction	Weak gauge bosons	86.97
Gravity	Graviton	0

The strongest of these is the 'strong nuclear force,' which governs the interactions of particles known as 'quarks,' of which larger particles, such as protons and neutrons (the two particles that form atomic nuclei) are composed. The strong force is responsible for the binding together of atomic nuclei, holding quarks together, mediated by the strong nuclear force's particle; the 'gluon'. Brian Greene states that we 'can think of gluons as the microscopic ingredient in the strong glue holding atomic nuclei together.'[133] Next there is the force we most commonly encounter in our day-to-day lives: electromagnetism. This force, mediated by photons, is responsible for the interactions between electrons. This is the force that contains what we refer to as 'light', with visible light being the mid range in a spectrum that extends from low frequency/high wavelength radio waves to high frequency/low wavelength gamma rays. Thirdly there is the weak nuclear force, whose particles – the weak gauge bosons[134] – govern radioactive decay through the seemingly spontaneous alteration of one type of quark into another, turning neutrons into protons, and one element into another. Finally there is gravity, the weakest of the four forces. Physicists believe that, at the

[133] Brian Greene, *The Elegant Universe*, p.11.
[134] Commonly written as W' and Z' bosons.

quantum level, gravity too has a mediating particle – the 'graviton' - although, so far, this particle has not been observed in nature, remaining purely theoretical.

Poem 16 – 'Waltz of the Nuclei' - explores the strong nuclear force. First proposed in 1964 independently by both Murray Gell-Mann and George Zweig, quarks were given their name by Gell-Mann after the line '*Three quarks for Muster Mark!*' in James Joyce's novel *Finnegans Wake*, and they are bound together by the gluons of the strong nuclear force.[135] The strong interaction differs from the other three forces in that a) it is much stronger, b) it operates over much smaller distances, and (c) it involves its own unique type of 'charge'. In *The Universe: A Biography* John Gribbin notes:

> Just as photons are associated with electric charge, gluons are associated with another kind of charge, which is called colour, but has nothing to do with colour in the everyday sense of the word. Whereas electric charge comes in only two varieties, positive and negative, colour charge comes in three varieties, given the names red, blue and green. [136]

'Red', 'green', and 'blue' are, essentially, *categories* of colour charge, but can be demonstrated through their conventional counterparts, in which the colours (visual) red, green, and blue, become representative of the categories of 'red', 'green', and 'blue' charge, which 'Waltz of the Nuclei' makes use of.

The piece uses the vocal melody of the widely known *canzone* 'La Donna è Mobile' from Verdi's opera *Rigoletto*, which uses the time signature 3/8. The upper number identifies how many beats there will be in each bar of music. In

[135] James Joyce, *Finnegans Wake* (London: Penguin Books, 2000) p.383.
[136] John Gribbin, *The Universe: A Biography* (London: Penguin Books, 2008) p.16.

the case of 'La Donna è Mobile' there are three beats to a bar, and this rhythm of the 'waltz' dictates the rhythm to which the lyrics are sung; in groups of three.

The piece appropriates and reframes the lyrics as broken word fragments arranged as a triangle. Each of these fragments consists of a syllable as sung, and each appears on screen according to the rhythm of the vocal section of the piece, visually 'playing' the melody. Rather than using a fragment of 'original' text, the piece merely re-presents the lyrics of the *canzone* in the visual form that recalls the presence of the three quarks in a nucleon. Kenneth Goldsmith explores this idea in *Uncreative Writing*:

> Even when we do something seemingly "uncreative" as retyping a few pages, we express ourselves in a variety of ways. The act of choosing and reframing tells us as much ourselves as our story about our mother's cancer operation.[137]

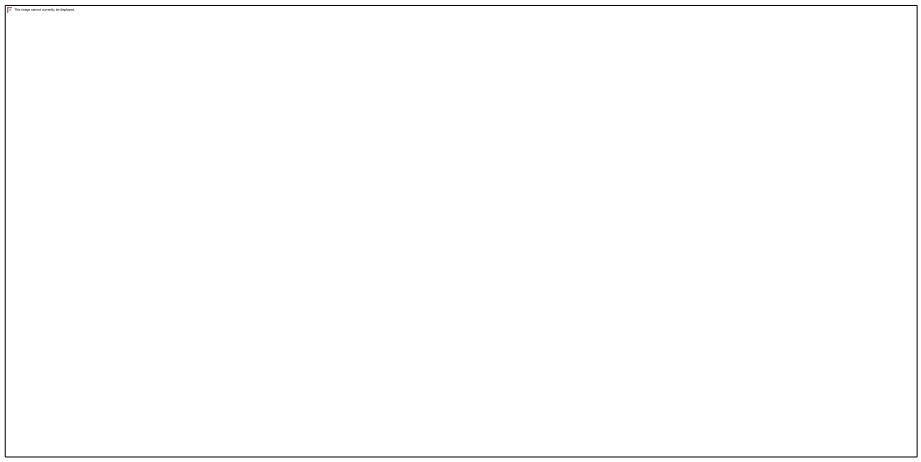
The lyrics in this configuration refers conceptually to the melody of the lyrics as sung, visually and musically emphasizing the 'figure of 3', referring back to the strong interaction. Each syllable is replaced incrementally with the word 'Quark', while continuing to follow the vocal melody. The lyrics are replaced until the entirety of what is being 'sung' visually by the poem consists entirely of 'triplets' of the word 'quark'. Coinciding with the crescendo of the first chorus, the three 'quarks' on screen are now also progressively connected by three appearances of the word 'gluon', each joining – bonding – one 'quark' to another. The three 'gluons' on screen also appear as red, green, and blue text, indicating their colour charge. As the screen appears to zoom out on this configuration, it identifies –

[137] Kenneth Goldsmith, *Uncreative Writing* (New York: Columbia University Press, 2011) p.9.

using arrows – the configuration of particular types of quarks – 'up' or 'down' and how the configuration of these two types of quarks determine whether a particle is a positively charged proton or a neutrally charged neutron. Continuing to zoom out further, the screen reveals and presents – still to the melody of 'La Donna è Mobile' – an illustration of an atom, identifying a single proton, a single neutron, and an orbiting electron.

Poem 17 – 'ElectroMagnetism' – explores the electromagnetic force. Though light itself has been discussed in the previous chapter, little has been said concerning its dynamics as a 'field' or the relationship that exists between electricity and magnetism. A 'field' in physics, describes the value of a particular force at each point in space. Michael Faraday, working in the 1820s, observed and described the way iron filings near a magnet revealed the presence of a magnetic field. Faraday observed that an electric field generates a magnetic field, and vice versa. This, when combined with the later work of Clerk Maxwell in 1873, would lead to the discovery that electricity and magnetism were, in fact, two different manifestations of the same fundamental force; electromagnetism. It is this idea of the self-perpetuation of electric and magnetic fields that is explored in 'ElectroMagnetism'.

The appearance of text in 'ElectroMagnetism' follows the musical rhythm of Philip Glass' 'Metamorphosis One' (which plays alongside the piece, performed by myself), which seems itself to have a self-perpetuating rhythm, consisting of variations of two different sections, both of which appear in the first two lines of music:



The first consists of pairs of chords that, from bar to bar, vary by just one note from bars 1-2 and 2-3, and by two notes from bars 3-4. Accompanying each chord, on the screen, the text of the poem begins to appear in pairings that coincide with the fall of each pair of chords. Two textual 'fingertips' appear, and along the outer edge of each 'fingertip', the word 'electrons' appears, running parallel to the curve of each 'fingertip', reminding the reader that, as biological cells are themselves composed ultimately of atoms, that outermost part of any area of skin would be a layer of electrons. These two 'fingertips' move towards one another, and between the two layers of 'electrons' the word 'photon' appears and disappears, wiping first from left to right, and then right to left, giving the impression of an exchange of photons as the two layers of negatively charged electrons in each finger tips repel each other.

The second line of music is probably the more identifiable as a self-perpetuating melody, consisting of alternating notes, not unlike an electric field giving way to a magnetic field giving way to an electric field, etc. With each note the words 'electric' and 'magnetic' alternate in a line across the screen, indicating a ray of electromagnetic energy. When this textual 'ray' has reached the right-hand side of the screen, a word cloud forms around it consisting of everyday (familiar) objects and actions that are a result of electromagnetism.

Coinciding with the *ritornellos* of the first melody (chords), the poem returns to the illustration of the fingertips, still in the act of touching each other. This time it is the exchange of 'photons' that accompanies the first chord pair. At the second pair, wiping left to right (and back) word 'repulsion' appears, followed by the word 'exclusion' on the third pair and then, on the final pair, the word 'sensation' appears on the inner side of each 'fingertip', indicating that the sensations felt in touching are, in fact, the result of repulsion caused by the electromagnetic force.

The next sequence, returning to the alternating melody, repeats it's original visualization, this time replacing the words 'electric' and 'magnetic' with repetitions of the word 'photon', accompanied by a word cloud of technologically themed daily human activities, relating the self-perpetuating electromagnetic field to both its mediating particle – the photon – and also to its impact on daily life. This is similar to Edwin Morgan's use of repetition in the final stanza of 'The Mouth' (see Chapter One).[138] The piece then re-presents both the pattern of alternating words 'electric' and 'magnetic' and the repeating 'photon' alongside each other, using their juxtaposition on the screen to emphasize their unification as a single force.

At the final *ritornellos* of the line of chord pairs, the 'fingertip' illustration also returns, repeating the same sequence as its previous iteration ('photon', 'repulsion', 'exclusion', 'sensation'). This time, on the fall of the new (fifth) chord

[138] Edwin Morgan, 'The Mouth', from *Collected Poems*, pp.388-9. In Morgan's piece, repetition is used to convey the apparent freezing of time at the event horizon of a black hole, produced by a perpetuating struggle between immense gravitational forces and the speed of light, whereas here it is used to demonstrate the 'freezing' of the pattern of electromagnetism, in which electric fields produce magnetic fields, and vice versa.

pair, adds a new piece of text at the bottom of the screen, in the repulsion space between the two 'fingertips'. This sequence is repeated three times, and on each instance the text that appears is different: on the first it reads 'Feel that?', on the second it reads 'The Field', and on the third it reads 'everything'. These final items of text coincide with the new chord pair, allowing the emphasis of the words to be carried and resonated through the chords.

Poem 18, 'Voyage of Weak and Decay', moves on to the second of the nuclear forces: the weak interaction, which is the force responsible for radioactive decay, a process in which neutrons spontaneously turn into protons. The title of the piece is taken from the 'Outline of Chapter Contents' of Joyce's *Finnegans Wake*, in which the description of Part II, Chapter IV (where the word 'quark' first appears) begins with 'Voyage of Tristan and Iseult'. Rather than presenting an 'original' text, it is the poetic text that begins this chapter of Joyce's novel that is represented and reframed throughout this piece. To include it in full here:

> ***- Three quarks for Muster Mark!***
> ***Sure he hasn't' got much of a bark***
> ***And sure any he has it's all beside the mark.***
> ***But O, Wreneagle Almighty, wouldn't un be a sky of a lark***
> *To see that old buzzard whooping about for uns shirt in the dark*
> *And he hunting round for uns speckled trousers around by Palmer-*
> *stown Park?*
> ***Hohohoho, moulty Mark!***
> *You're the rummest old rooster ever flopped out of a Noah's ark*
> ***And you think you're the cock of the wark.***
> *Fowl's up! Tristy's the spry young spark*
> *That'll tread her and wed her and bed her and red her*

Without ever winking the tail of a feather
And that's how that chap's going to make his money and his mark![139]

The emboldened appear in the poem. The first line - '*Three quarks for Muster Mark!'* – appears along with a visualization consisting of a single 'One up!' and two 'One down!' configured in a triangular formation, connecting the '*three quarks for Muster* Mark' with the internal structure of a neutron (consisting of two down quarks and one up quark). Between them a letter 'Z' drifts from one to the other (causing no change) representing the neutral Z boson of the weak interaction. With the appearance of the second two lines ('*sure he hasn't . . . beside the mark*) alongside this particular visualization, the lack of 'much of a bark' is reframed to refer to the electric neutrality of the Z boson and its inability to effect a change in the flavor of the particles in question. The 'Z' completes a second revolution from quark to quark while the three lines of Joyce's text remain on screen, changing '*Three quarks*' to 'A neutron', linguistically zooming out and identifying the specific nucleon formed by this configuration of quarks.

The cycle of the 'Z' continues as the text moves on to present the line '*O, Wreneagle Almighty, wouldn't un be a sky of a lark…'* in a very playful context, as the subtext of the piece proposes 'wouldn't it be funny if…' Following this, a 'W-' appears and drifts away from the 'One Down!', and 'One Down!' is replaced by 'One Up!'; a down quark has become an up quark, and the neutron has become a proton. Continuing with the playful tone, the piece addresses the reader jokingly with Joyce's line *'And you think you're cock of the wark!',* drawing comparison between the rich and dynamic world of the quantum microcosm, and the relative mundanity of the human mediocosm. Here 'moulty' is given a very definite

[139] James Joyce, *Finnegans Wake*, p.383.

context that uses its similarity to 'molting', describing the emission of the W^- boson as a molting of a down quark into an up quark. The piece now repeats the cycle of the 'Z' with this new configuration, re-presenting the line '*Three quarks for Muster Mark!*' and, as before, changing the '*Three quarks*', this time into 'A proton', indicating that the transformation of one nucleon into another.

The piece then displays a multitude of neutrons emitting their own W^- particles and becoming neutrons, while the line 'A proton now *for Muster Mark!*' remains displayed. To indicate a passage of time, the piece then jumps to the appearance of a single dot, then a second, then a third, forming a kinetic ellipsis on the screen. Following this graphemechanical 'fast-forward', the piece changes its form and its speed. The piece ends with a variant on one of Joyce's lines: 'Still *think you're the cock of the wark?*' reframing it as a question posed to the reader, calling anthropocentrism into question.

Poem 19, 'The Graviton', differs somewhat from the others in that gravity's mediating particle – the graviton - has not been proven to exist, presently being only a theoretical prediction. Should this particle exist, it would be extremely difficult to identify.[140] Mathematically the existence of such a particle is far from inconceivable. Its elusiveness, however, lies in its weakness as a force. A paper entitled 'Can Gravitons Be Detected' by Tony Rothman and Stephen Boughn concludes that:

> At this stage, the only possibility for detecting gravitational bremsstrahlung appears to be putting [a] Jupiter-mass detector in close

[140] In *The Elegant Universe*, Brian Greene notes that '[electromagnetism] is about a million billion billion billion billion (10^{42}) times stronger [than gravity]' (p.12).

> orbit around a white dwarf or neutron star; the latter might result in as many as 10^{-2} detections per year.[141]

Assuming it operates at 100% efficiency, that would mean being able to observe just a single graviton every ten years. It is around this idea - the graviton's elusive absence – that the piece is constructed.

The language of the poem is the voice of a graviton. It begins by describing the properties of gravity, namely the ironic combination of its vast scale and its feebleness in comparison to the other three forces. The voice translates this into human experiences of gravity, from insignificant and common place incidents such as an apple falling from a tree, to colossal and life-altering tragedies with 'a crashed plane and towers smashed and fallen', alluding to the September 11th, 2001 terrorist attacks, casting gravity as both mundane, and terrifying in its capability and potential. The 'apple' alludes to the popular story that Isaac Newton discovered his law of gravitation after an apple had fallen on his head. The piece then goes on to describe the weakness of gravity as a force – 'we touch your world / oh-so-softly / harsh enough to feel / far too gentle for real eyes / to realize'. By this point it is clear that the positioning of each line of text marks the outline of something specific, and as it reaches around 'cold unfeeling' it becomes evident that the shape it is forming is, in fact, the letter 'G'. The final few lines, becoming much more angular in their orientation, giving the text as a whole the visual impression of an outwardly expanding spiral, while moving into the difficulties of observing the graviton, ending with an address to the reader that they would be lucky to manage to observe one of

[141] Tony Rothman and Steven Boughn, 'Can Gravitons Be Detected', Foundations of Physics, 36, (2006), 1801-1825.'Bremsstrahlung refers to the electromagnetic energy emited when a particle undergoes a collision which changes its velocity.

them [the gravitons] every ten years. As the piece concludes, the 'G' formed by the positions of the lines of text is revealed to be an absence marked by the presence of the text, an area of black background that, like Deleuze's black sky, does not distinguish itself by the text, but is itself distinguished by the appearance and the formation of the text, distinguishing that which does not distinguish itself.[142] As with 'H', this is, again, the opposite effect of Bernstein's 'This Poem Intentionally Blank'.[143] Here the text marks a simulation of the presence of the graviton by defining its absence, just as the graviton in physics is felt through its absence from experimental confirmation.

The space of the page/screen (the distance between words/lines, their orientation toward/away from each other, etc.) can be thought of, here, as the 'gravity' of a text. In his essay 'Projective Verse', Charles Olson notes that 'form is never more than an extension of content', relative concerning the spaces between objects that interact.[144] In writing the space of this interaction is the blank space of the page/screen, against which the writer constructs his work, the form of which against the blank space determines and governs its interactions. Here, the gravity is that of the graviton, the space carved by the text that forms the letter 'G'; the subject of the poem marked and identified in the blank space of

[142] Gilles Deleuze, *Difference and Repetition* (London: Continuum Books, 2012) p.36. 'Lightening, for example, distinguishes itself from the black sky but must also trail it behind, as though it were distinguishing itself from that which does not distinguish itself from it.'

[143] Charles Bernstein, 'This Poem Intentionally Left Blank', p.245. The irony of Bernstein's piece lies in the text's distinction from the intended blankness of the page, whereas here the text causes the blank background of the screen to distinguish itself from the text.

[144] Charles Olson, 'Projective Verse', from *Norton Anthology of Postmodern American Poetry*, p.614.

the screen, in the interaction of distances between the lines, by being absent from the text of the poem.

Introducing Quantum Mechanics (Poems 20-23)

Poem 20, 'Between the Slits', returns to problem posed by Einstein's work and the double slit experiment. The question posed by 'Double Slit: Part Two' is this; if light exists as particles how would it pass through both slits in order to form the interference pattern? Conventional logic dictates that photons of light should pass through one slit or the other, but in doing so they could not produce the interference pattern seen on the screen at the end.

A logical solution would be to place photon detectors over both of the slits to see which slit these particles of light pass through. However, as John Gribbin writes in his book *In Search of Shrödinger's Cat*, when this occurs something odd happens (using electrons instead of photons):

> Imagine an arrangement that records which hole an electron goes through but lets it pass on its way to the detector screen. Now the electrons behave like normal, self-respecting everyday particles. We always see an electron at one hole or the other, never both at once. And now the pattern that builds up on the detector screen is exactly equivalent to the pattern for bullets, with no trace of interference . . . When we try to look at a spread out electron wave, it collapses into a definite particle, but when we are not looking it keeps its options open.[145]

[145] John Gribbin, *In Search of Schrödinger's Cat* (London: Black Swan Books, 1991) p.171.

It doesn't really matter whether we talk about electrons or photons; trying to observe any subatomic particle going through one slit or the other the interference pattern will disappear, and when we don't try to observe this the interference pattern reappear. This is the focus of this poem.

The piece presents the reader with a series of elements – the light source, the double-slit screen, the final screen, and the detector – and a single haiku (referring to the discrete nature of the particle) of hypertext that invites the reader to attempt to see what happens between the slits. When the reader clicks on this hypertext, the piece reveals which of the slits the photon passes through, while the interference pattern vanishes, with most of the text of the haiku disappearing, leaving only the words 'We can try'. The information is displayed visually, but not explicitly stated, inviting the reader to reach the conclusion through investigation/experimentation. This is both a graphemechanical and ergodic piece in which the reader forms an essential component of the piece, as well as the fact that it can't be spoken out loud; it must be read/interacted with, existing as an electronic writing system. The reader manipulates the hypertext at their leisure, able to activate the textual photon detectors, observe the effect, deactivate them, and repeat, making it continually possible to transform the history of the piece, moving back and forth at will until the conclusion is understood. This is similar to the second scene in Bouchardon's 'Loss of Grasp', in which the user is briefly free to play with the various speech options at the narrator's first encounter with the beautiful woman (see Chapter One).[146] All that is presented is the elements of the experiment, and even these elements are appropriated; the objects are appropriated by the visual signification of the

[146] Serge Bouchardon, *Loss of Grasp, 2010*, http://lossofgrasp.com.

words, the words themselves are appropriated as visual signifiers of the objects, and even the reader is appropriated as a component of the text, to convey a coded message, a conclusion of physical reality.

Poem 21, 'When You Try to See', further clarifies the resolution to the conflicting theories of light. A Brian Greene writes:

> The photoelectric effect shows that light has particle properties. The double-slit experiment shows that light manifests the interference properties of waves. Together they show that light has *both wave-like and particle-like properties*.[147]

This exhibiting both wave-like and particle-like behavior has been characterized by many physicists and science writers as a 'superposition', the simultaneous probable occurrence of all possible states until it is observed. A literary corollary can be found in of Raymond Queneau's *Cent Mille Milliards Des Poémes*, a collection of ten sonnets, the lines of which can be shuffled into new sonnets. On this Jacques Bens notes:

> One sees, then, all that makes for the potentiality of the *Cent Mille Milliards Des Poémes:* it is not the only example, the archetype they constitute, but also the ninety-nine trillion nine hundred ninety-nine billion nine hundred ninety-nine hundred ninety-nine thousand nine hundred ninety sonnets that are found, inexpressed but *in potential*, in the ten others.[148]

[147] Brian Greene, *The Elegant Universe*, p.103.
[148] Jacques Bens, 'Queneau Oulipian', from *Oulipo: A Primer of Potential Literature*, (ed.) Warren Motte, (Illinois: Dalkey Archive Press, 1998) p.65.

'When You Try To See' focuses specifically on the wave/particle duality within the context of the double-slit experiment, demonstrating the reconciliation of these two concepts through their negation and the emergence of something that is beyond the ability of language to convey. This specific inability of language lies at the heart of the piece.

The poem initially appears to consist of three columns, similar to some of the pieces contained in Ira Lightman's collection *Duetcetera,* which features two (or three) separate poems juxtaposed to form either a disjointed single piece or two/three conflicting pieces occurring at once.[149] In 'When You Try To See', each line of the piece presents a seemingly self-contained image that coheres into a whole, arranged on the page in the form of a wave. This wave, however is really 'particles' of text arranged as a wave on the page. The wave gradually shrinks inwards towards the center, so that by the end of the poem the wave and particle have lost their distinction, as the language of the piece describes the emergence of a new concept that escapes conventional language. This is not entirely unlike Harry Matthews' 'Liminal Poem', in which the text expands expressing a desire for new and innovative poetic forms, and then contracts into a unified point as it lists the names of the key members of the OuLiPo, culminating with the initials of its founding members (Francois Le Lionnais and Raymond Queneau).[150] The central text, in bold, remains strictly neutral in its content, using only single words – names of subatomic particles, technical terms etc. – acting as a balance between both the text swinging to the left and right and the warring 'wave' and 'particle' views that, around this axis, come to reconciliation.

[149] Ira Lightman, *Duetcetera.*
[150] Harry Matthews, 'Liminal Poem', from *Oulipo: A Primer of Potential Literature*, (ed.) Warren Motte, p.25.

When conventional language tries to describe something that is both a wave and a particle (and neither), we realize that it is something that completely departs from human experience. 'When you Try To See' makes no attempt at conveying or describing what, exactly, this duality is. Instead, it makes this inability of conventional language its conclusion, using it to portray physics as it is, beyond the 'human'. Views of light as either a particle or a wave gradually reduce in distance between one another, until they become neither wave nor particle, but a mixture of both; a new 'identity'.

Poem 22, 'The Differance', focuses on demonstrating that a similar duality actually exists within language itself. It concerns the unification of binary terms that are often spoken of as though their very nature insists on their opposition: particle/wave, male/female, matter/force, letter/sentence. In order to understand something that can be both a wave and a particle, we find ourselves in need of a paradigm shift in the way conventional thought approaches these binary pairs.

The initial idea comes from the binary opposition of public toilets, commonly marked with 'Male' and the 'Female' signs. Considering this in the context of the wave/particle duality, and thinking of the human being as a collection of information (as opposed to a purely biological entity) it suggests that the two door signs present a 'difference' where there is none, or rather each individual, regardless of gender, differs anyway in terms of the content of their informational pattern.

Replacing the 'Male' and 'Female' with the 'discrete' and the 'continuous', the beginning of the piece is a conceptual reconstruction of the doors, inviting the reader to 'Approach' them on the screen. The 'Male' and 'Female' figures are

constructed from the words 'Matter' and 'Force', and the reader is now presented with the choice of which to enter. Upon making their first choice the 'door' is opened, and they are shown a glimpse of a 'room' of text. The reader now has two further options; to click on the same 'room' again, or to open the other 'door'. The subject of either text is the 'discreteness' (through the 'Matter' door on the left) and the 'continuousness' (through the 'Force' door on the right) of language, substituting 'letter/word' for 'particle' and 'sentence/narrative' for 'wave'.

There are three 'levels' of text for each door, all of which begin with a strict argument for language being 'particle-like' or being 'wave-like'. At the first level, the subject of each door distinguishes the discrete from the continuous. This is, however, turned around by the presentation of the language itself. In the structuring of (A) or (B) it is impossible to determine whether it is the discrete or the continuous that is distinguishing itself or which is being distinguished from, due to visual interference. This visual interference is also the reason that the poem's title – 'The Differance' is spelled with an 'a', as Derrida used the term.

The second 'level' of each 'door', as if responding to the text that preceded it (either of the same 'door' or the other), acknowledges the role of their 'adversary' in relation to themselves. The 'discrete' – the letter, the word – accepts that it relies on the relationship – the continuousness – that creates meaning between each as part of a process, and the 'continuous' – sentence, paragraph, narrative – accepts that a relationship is useless without discrete elements to relate. When the third 'level' is reached, the text is forced, finally, to accept that it is neither discrete *nor* continuous, but both. The elements of language must relate to each other in order for meaning to occur, and without

those elements no relationship can form. The text of either 'door' on its own will not make sense, and the lines now alternate between the unpunctuated/spaced and the spaced/unpunctuated. Only when the third 'level' of the opposing 'door' can the lines of text be read, the lines of one 'door' completing the lines of the other. This, again, builds on the principle behind the poems of Lightman's *Duetcetera,* however, here, the one side's completion of the other is not an ambiguous possibility left up to the reader, but a necessary act asked of the reader.[151] *Now*, there can be neither a language that is 'wave-like' or a language that is 'particulate'; they are no longer separate. One flows into the other, and both must be read in relation to each other **and** as part of each other.

Poem 23, 'The Wavicle', considers something that is both a wave and a particle; a natural question to ask would be 'what would this 'thing' look like *if it were possible* to see it?', similar to the premise of Brian Kim Stefans' 'The Dreamlife of Letters'.[152] The title is taken from a proposed name for something that is both a wave and a particle. 'The Wavicle' draws from the work of the physicist Max Born, who, building on the work of other physicists such as Erwin Schrodinger, Louis de Broglie, and Werner Heisenberg, conceived of the 'probability wave', or the 'wave function' as a replacement for the classical wave **or** particle paradigm. In this view, anything in the subatomic world would, rather than having a fixed and definite position in space-time, be described by a wave function that covered every point in space-time, and at every point that subatomic 'wavicle' would have a probability of being found. This probability would vary from point to point, so that a particle technically existed everywhere

[151] Ira Lightman, *Duetcetera*.
[152] Brian Kim Stefans, *The Dreamlife of Letters*, 2000, http://collection.eliterature.org/1/works/stefans_the_dreamlife_of_letters.html

'probably', but was most likely to exist in those areas where its probability of being found was highest.

The poem consists of a single sentence that never ends; 'I am over here and over here'. The first instance of 'I am over here' is placed in the center, and the following words – 'and over here' are repeated constantly, radiating outwards in all directions. The words themselves are shaded: darkest in the center, becoming fainter the further out. Once the sentence begins it repeats over and over, to an infinity that is glimpsed through the page; the poem extends infinitely, but 'occurs' only once, and in one space. The repeated words are by no means equivalences, that is, the same that occurs over and over, in which each instance can be exchanged for another. As Deleuze says of repetition:

> To repeat is to behave in a certain manner, but in relation to something unique or singular which has no equal or equivalent. And perhaps this repetition at the level of external conduct echoes, for its own part, a secret vibration which animates it, a more profound, internal repetition within the singular.[153]

Each repetition in the piece – each 'vibration' – denotes in itself the probability of the location of 'the' text (and the wavicle), and yet 'echoes' out across the page, leaving the reader both unable to determine a specific location, and yet able to distinguish the 'more likely' locations. The darker the text is, the more evident (against the white space of the page) it appears to be, and the more likely the reader's eyes are to be drawn to it, the darkest of which lies at the center, the beginning of the sentence, and the most likely location of 'the' text (wavicle).

[153] Gilles Deleuze, *Difference and Repetition*, pp.1-2.

The reader is 'shown' a visual construct of what the 'wavicle' might look like (if it could be seen by human eyes) as both wave **and** particle; something that probably exists in one location, and probably in another, more probable in some locations than others, with the number of probable locations expanding out across the universe. The conceptual framework regarding the simultaneity of the discrete and the continuous is here given a visual form, and the reader can 'see' the wavicle as it 'would' be 'seen'; a simulation of the wave/particle duality.

Quantum Weirdness (Poems 24-28)

Poem 24, 'Schrödinger's Cat', takes the name given to a thought experiment proposed by physicist Erwin Schrödinger in response to what came to be known as the 'Copenhagen interpretation' of quantum mechanics. Although Schrödinger intended it as a *reductio ad absurdum*, it nevertheless reflects quantum mechanical effects of observation, but is also a clear illustration of some very real implications of the quantum hypothesis. At the start of his book *In Search of Schrödinger's Cat*, John Gribbin summarizes the experiment:

> Schrödinger . . . [imagined] an experiment set up in a closed room, or box, which also contains a live cat and a phial of poison, so arranged that if the radioactive decay does occur, then the poison container is broken and the cat dies. In the everyday world, there is a fifty-fifty chance that the cat will be killed, and without looking inside the box we can say, quite happily, that the cat inside is either dead or alive. But now we encounter the strangeness of the quantum world . . . The atomic decay has neither

> happened nor not happened, the cat has neither been killed or not killed, until we look inside the box to see what has happened. [154]

The state that this theoretical cat occupies while it is in the box is a 'superposition' of all possible states exactly like the image of the 'wavicle'. The act of opening the box causes an instant known as 'decoherence'. Theoretical physicist Michio Kaku describes this in his book *Parallel Worlds*:

> The cat is in constant contact with the molecules of air, the box, and even cosmic rays that pass through the experiment. These interactions, no matter how small, radically affect the wave function: if the wave function is disturbed to the slightest degree, then the wave function splits into two distinct wave functions of the dead cat or the live cat, which no longer interact.[155]

Both the set up of the thought experiment itself and this instance of 'decoherence' are important in considering this poem.

'Schrödinger's Cat', using acetate, presents two poems in parallel columns. The acetate is initially 'closed', like the box in which lies the cat that is both alive and dead. The two columns themselves are variations on the same theme, differing only in specific lines to create one section in which the cat is alive, and one in which the cat is dead. Certain words/phrases that appear in both sections (in the same places) are both emboldened and presented in red. When the piece is folded – at its start – the two columns blur together and the two texts appear simultaneously through the acetate, and, because there are lines that describe the cat as either alive and as dead, the differences in each clash, making it

[154] John Gribbin, *In Search of Schrödinger's Cat*', p.2.
[155] Michio Kaku, *Parallel Worlds*, pp.166-7.

impossible to 'read' the cat as either alive or dead. The only clear text is a third section – the bold, red text – hidden in each, which is amplified in the folding, and in this state, standing out against the black text, describes the set-up of the experiment, before inviting the reader to open the 'box'. Once opened, the reader will find that they now have two pieces, one in which the cat is dead, and the other in which it is alive.

This piece, through its physical form and through the act of folding/unfolding, reconstructs the principle of the Schrodinger's Cat experiment, operating in two successive and sequential stages: (1) folded, (the box unopened), and (2) unfolded, (the box opened). At stage (1) the poem exists as two different poems simultaneously, which, in the act of 'opening', decoheres, becoming one or the other, the effect of observation being the gaze of the reader. In its initial state – (1) – the two states of the cat are unknowable, as the differing words/phrases interfere with each other, making use of the transparency of the acetate in reconstructing an intrinsic subjectivity of reality. Just as, in Jim Andrews' *Stir Fry Texts*, a single textual state only emerges once the cursor is removed, here there are two possible states while folded, and as soon as the piece is unfolded (2) one single state emerges.[156]In order for one full section to be read, decoherence from the 'folded' must occur, and this occurs when the reader interacts with (disturbs) the piece.

Poem 25, 'Quantum Window', focuses on a very specific and simple principle of quantum probability arising from the quantum view of light within

[156] Jim Andrews, *Stir Fry Texts*, 1999-2000, http://www.vispo.com/StirFryTexts While Andrews' texts contain many more possible textual states than this poem, owing to the flexibility and capacity of the electronic medium, here only two possibilities are required, and as such the folded acetate is a much more appropriate choice, being able to physically show the division.

the context of a simple reflection. Looking through a window, a person will see two things; what lies beyond the window, and a faint reflection of themselves. This is because about 96% of light passes *out* through the window, while light travels *in* to the observer's eyes, and 4% is reflected back without passing through. This is easily explained if light is a wave: part of the wave is reflected (4%), and part of it passes through (96%). However, as we know, light has a particulate nature too, one that needs explaining. As Richard Feynman writes:

> For every 100 photons that go straight down towards the glass at 90°, an average of 4 arrive at A and 96 arrive at B. So "partial reflection" in this case means that 4% of the photons are reflected by the front of the glass, while the other 96% are transmitted . . . We cannot predict whether a photon will arrive at A or B. All we can predict is that out of 100 photons that come down, an average of 4 will be reflected by the front surface.[157]

Each photon has, approximately, a 96% *probability* of passing through the glass, and a 4% *probability* of being reflected, with no actual mechanism that determines one or the other.

The piece itself is a fairly literal reconstruction of the light/glass set up. Replacing the glass with acetate and the scene beyond the window with a black background beyond, the text of the piece is presented within an oval, describing the principle of the 'quantum window' in a prose-poem form.[158] The reader is asked to align their face with the oval so that they can see the reflection, the text, and the background image at once. The reader sees the text against the

[157] Richard P. Feynman, *QED: The Strange Theory of Light and Matter* (London: Penguin Books, 1990) pp.17-9.
[158] The black background is purely to enhance the clarity of the reflected image of the reader.

backdrop, sees the image in the background beyond the window, sees his/her reflection in the acetate, all as they holds the poem as a physical object an appropriate distance from his/her face (a physical 'gap'). The text itself follows a similar explanatory tone to that of Lucretius in *On the Nature of the Universe*, poetically describing the concept while making use of simple statements that follow logical progression.[159] Reading the piece, seeing both their own reflection and the image of the background, looking for an explanation in the text that hangs between the two, only to find that the most detailed explanation is that it happens, either way, because there is a chance of it happening, and the only thing that can be known is what the chances themselves are. It is not possible for the reader to experience the determination of reflection/transmission within the piece, just as it is not possible for the observer looking through a window, because all that happens in a gap to which we are quite physically barred.

It is the 'finality' of probability that is explored and demonstrated in this piece. Instead of giving a concrete answer – as one might expect a scientific answer to be – science responds by giving an answer which admits that reality is subjective and largely influenced by events that don't happen, that might not happen, that we don't see happening, but nevertheless play an un-ignorable role in determining what does happen and what we can see happening, as well as the revelation of the imposed limits of the knowledge of physical laws.

Poem 26, 'Uncertainty', continues the theme of the limit of knowing, focusing on one of the most famous principles of quantum mechanics – the Uncertainty Principle. Discovered in 1927 by German physicist Werner Heisenberg, this reveals that there are limitations imposed on exactly how

[159] Lucretius, trans. by Ronald Melville, *On The Nature of the Universe.*

accurately something can be measured (within quantum mechanics) that, far from being a matter of human capability, are a fundamental feature of nature. As Stephen Hawking writes:

> The more accurately you try to measure the position of a particle, the less accurately you can measure its speed, and vice versa.[160]

Heisenberg's revelation deconstructed the classical determinist view in a very Derridean manner – from within the principles of determinism itself; it is not possible to know *both* a particle's speed *and* its position at the same time. In a literary context, we can consider someone reading a copy of Vladimir Nabokov's novel *Pale Fire*, which is constructed of both a poem and a prose commentary. The reader can either read the commentary or the poem, but never at the same time.[161] Physicist Brian Greene, in his book *The Fabric of the Cosmos,* uses a different (and more common) illustration, one on which the poem is based.

> To understand it, think of the prix-fixe menus in certain Chinese restaurants. Dishes are arranged in two columns, A and B, and if, for example, you order the first dish in column A, you are not allowed to order the first dish in column B; if you order the second dish in column A, you are not allowed to order the second dish in column B, and so forth . . . [162]

The prix-fixe restaurant analogy Greene gives provides the structure of the piece 'Uncertainty'. As an electronic piece, it takes the form of an invitation to the reader to 'make an order' from one of two 'menus' – labeled 'A' and 'B' – one of

[160] Stephen Hawking, *A Brief History of Time* (London: Bantam Books, 1997) p.61.
[161] Vladimir Nabokov, *Pale Fire* (London: Penguin Books, 2011.
[162] Brian Greene, *The Fabric of the Cosmos* (London: Penguin Books, 2004) p.95.

which offers the 'location' of a particle, and the other offering its 'speed'. Each selection the reader makes causes two changes to occur, the most overt being a single line of text that is split into two parts, the first half (marked with a capital letter and appearing higher than the second) appearing under the 'menu' that was selected, and the second half appearing (lower) underneath the 'menu' that was not selected. The second change, somewhat subtler, is that the red text inside each of the 'menus' (saying 'I'd like to know your position/speed') becomes either more transparent or opaque, depending on whether it was selected or not. Each of these appears at 50% transparency to begin with, and whenever a selection is made this transparency is decreased (increasing the opaqueness) in the selected by 10%, simultaneously increasing the transparency of the un-selected by 10%. Therefore, the clearer one 'menu' becomes, the more transparent the other becomes, until, at the end, one appears to be almost completely opaque, and the other almost invisible. The actual language of the poem explores and explains what is going on in this dynamic, occurring alongside it, allowing the reader to both 'see' and 'read' the effect of Heisenberg's uncertainty principle through the (very human) signification that the form of the 'menu' brings. In this way, the transparent/opaque transitions are supplemented by the text, which forms a narrative around the principles of quantum uncertainty. This interacts with, translates, and imposes an order of meaning on the 'data' given by the simple act of becoming more/less transparent, refining it and allowing what is 'seen' to become something that can be 'understood'.

Quantum mechanics – the uncertainty principle in particular – revealed that reality itself was a subjective experience. Reality is formed of both that which is 'present' and 'absent'. In the piece the opaqueness/transparency of each

stand out against each other, in relation to each other. Their perceived presence/absence is a direct result – and a fundamental part of – the interactions of the reader, just as the observations of the physicist have the same impact on the measuring of the position/speed of a particle. The attempt to know something - quite literally, in physics –involves, as a consequence, not being able to know something else.

Poem 27, 'Cogito Ergo Sum Over History', deals with the implications of the probabilistic nature of the 'wavicle' in relation to the real world. The piece takes its title from the merging of the famed quote of Descartes' ('I think, therefore I am), and Richard Feynman's 'sum over history' approach to quantum electrodynamics. As Brian Greene writes:

> Feynman . . . [showed] that a probability wave embodies all possible pasts that could have preceded a given observation, and illustrates well that to succeed where classical physics failed, quantum mechanics had to substantially broaden the framework of history.[163]

The meaning of the title, therefore, translates into 'I think, therefore I am more than the mere sum of my histories'.

The piece begins with a quote from astrophysicist Neil DeGrasse Tyson's essay 'On Being Baffled' in which he refers to Richard Feynman, drawing attention to how modern concepts of physics, though extensively tested and supported by both experimental and theoretical evidence, seem to be so divorced from perceived reality.[164] The piece then begins to discuss the 'wavicle'

[163] Brian Greene, *The Fabric of the Cosmos*, p.180.
[164] Neil DeGrasse Tyson, *Death By Black Hole and Other Cosmic Quandaries*, p.304. 'Figuring out the laws of physics is like observing a game of chess without

in terms of its probability, that each one of these probabilities is, in itself, a history, reality being the final sum of all of these possibilities. This is very reminiscent of Ludwig Wittgenstein in *Tractatus Logico Philosophicus*:

> If things can occur in states of affairs, this possibility must be in them from the beginning . . . If I can imagine objects combined in states of affairs, I cannot imagine them excluded from the possibility of such combinations.[165]

At each point, as in 'The Wavicle', we see a possible state of affairs, a 'what could be'. This is something emphasized by the text, which appears on screen one line at a time, at seemingly random locations on the screen. The piece moves on to point out that the principle of 'sum over history' – formulated in physics by Richard Feynman – has, itself, also emerged in literature in Roland Barthes' essay 'The Death of the Author'. He writes:

> We now know that a text is not a line of words releasing a single 'theological meaning (the message of the Author-God) but a multi-dimensional space in which a variety of writings, none of them original, blend and clash. The text is a tissue of quotations drawn from the innumerable centers of culture.[166]

Barthes' notion of a 'tissue of quotations' actually creates the form/structure of the second section of the piece, which moves on to demonstrate this principle.

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knowing the rules. Worse yet, he wrote, you don't get to see each move in sequence.'

[165] Ludwig Wittgenstein, *Tractatus Logico Philosophicus*, (New York: Routledge Classics, 2001) p.6.

[166] Roland Barthes, 'Death of the Author', from *Image Music Text*, p.146.

In the second section, this principle discussed in 'The Death of the Author' becomes a vehicle to 'show' the reader the meaning behind Feynman's 'sum over history'. Brief lines of text begin to appear in seemingly random locations on the screen. These events are 'influences' – namely, my own; the just part of the vast web of interactions, people, books, works, and things that have happened to me that have influenced and directed me and my writing. Eventually, as the reader observes more and more of these 'texts' appear on the screen, and the shape becomes clearer, culminating in the 'event'; the formation of the word 'TEXT' composed entirely of 'texts' that are no longer decipherable or meaningful. Everything overlaps and obscures everything else, leaving the only thing on screen that matters - the 'Text'; the 'sum' of its 'histories'. Derrida wrote of the same thing in his piece 'The Deaths of Roland Barthes':

> It is inevitable [fatal], both just and unjust, that the most "autobiographical" books (those of the end, as I have heard said) begin at death to conceal all the other books. What is more, they begin with death.[167]

This 'TEXT' begins with its completion, and at that point everything that came before, gradually forming the shape of each letter, become irrelevant, 'concealed' by what is, quite literally, an 'autobiographical' 'TEXT'.

In the end, it is the addition of all of these 'texts' – which themselves become probabilities in relation to the path of a life (mine) – that form the 'TEXT' – which, if we approach Derrida's principle that 'there is nothing outside the text' in quite a literal sense within this piece, becomes the 'final state' of the wavicle

[167] Jacques Derrida, 'The Deaths of Roland Barthes, from *The Work of Mourning* (London: University of Chicago Press, 2001) p.66.

(the apparent outcome, such as the interference pattern in the double slit experiment) – and the 'TEXT' can only be found as the 'sum' of these probabilities. This demonstrates, through a duality of physics and literature, the application of the 'wavicle' and its vast wealth of probabilities in reality; that it exists as a composite of these probable outcomes.

Poem 28, 'Antimatter', demonstrates the relationship between matter and antimatter in quantum mechanics. The existence of antimatter was predicted by physicist Paul Dirac in 1928, four years before it was experimentally/observationally discovered.. In his biography of Dirac, *The Strangest Man*, Graham Farmelo describes the evolution of Dirac's prediction, which, at the time, was being described as 'hole theory':

> [Dirac] imagined all the electrons in the universe gradually filling up the energy states: the states with negative energy will be populated first, because they have lower energies. Only when they are full will electrons occupy positive energy states. Because the negative-energy states are full, there are no vacancies into which these positive-energy electrons can jump . . . Dirac argued that this sea has a constant density everywhere, so that experimenters can observe only departures from this perfect uniformity . . . Only a disturbance in Dirac's sea – a bursting bubble, for example – would be observable. He envisaged just this when he foresaw that there would be some vacant states in the sea of negative-energy electrons, causing tiny departures from the otherwise perfect uniformity. Dirac called these unoccupied states 'holes'.[168]

'Antimatter' seeks to reconstruct this 'sea' by creating a conceptual space that represents both the quantum field and theses virtual particles. This is achieved,

[168] Graeme Farmelo, *The Strangest Man* (London: Faber and Faber, 2009) pp.166-7.

in an electronic form, with a grid of squares that, overall, forms a section of theoretical space – our 'field'. Each square within the grid represents one of Dirac's energy states, a virtual particle. These states are particles that 'could' happen, that have a probability of popping into existence. The text, describing the process of the creation of matter/antimatter pairs, appears slowly, one word at a time, a single letter (or space/punctuation) occupying a single square, read line by line as it appears, eventually presented in a similar way to the presentation of text in Angela Ferraiolo's 'The End of Capitalism'.[169] Alongside this, a single square will, seemingly at random, disappear, leaving behind only a black 'hole' in the grid. This shows the 'disturbance' through which we can detect antimatter. The white square – the potential electron, for example – due to quantum fluctuations, bursts into existence as a virtual particle. Conversely, the hole it leaves behind in the potential sea, is felt in reality as an anti-particle, in this case, a positron; a positive electron. With every appearance of new text, one 'hole' appears, and disappears upon the next appearance, annihilating, and returning to a potential state (giving way to a new 'hole' etc.), the constant shifting of this forming a representation of these kinds of quantum fluctuations.

[169] Angela Ferraiolo, 'The End of Capitalism', 2009 http://angelaferraiolo.com/end_of_capitalism/capitalism.html In Ferraiolo's piece, in between footage of New York, text is presented in a very plain, almost grid-like fashion against a background sea that seems to mimic the fluctuating mechanistic processes of a computer program.

Chapter 4: Themes of Universality

Origins of the Universe (Poems 29-31)

This chapter extends the discussions of the two previous chapters to their effects at a universal scale, uniting the physics of the extremely large – galaxies, stars, planets, etc. – and the extremely small, i.e. the quantum world.

Poem 29 – 'It's Kind of Like the Theme to Star Wars' – begins the chapter's exploration of astrophysics on the theory behind the creation of the universe. The 'big bang theory' began with a series of discoveries across the 1920s by astronomer Edwin Hubble. He observed that the many galaxies of the universe are moving apart, and realized that if this were so they must have been closer together at one point. Eventually, there would be a point at which all matter/energy must have all been located at a single point of near infinite.

'It's Kind of Like the Theme to Star Wars' discusses this initial phase of the big bang theory by comparing it to the iconic theme of the science fiction franchise *Star Wars*, composed by John Williams in 1977. Visually the piece reconstructs the style of the films' now-famous 'crawl text'. Set against a black backdrop, the piece starts with a single phrase of text that in color, style, and content mimics the phrase that begins every *Star Wars* film; "A long time ago, in a galaxy far, far away…." (keeping the unusual use of four dots as ellipsis just as the film does). The text as read in the poem, however, parodies this, reading "The longest time ago", referring to the fact that the big bang marks the beginning of time, "in a universe that is never far away….", referring to the big bang as an expansion of space itself. Following this, the word 'BANG' appears in text composed only of a thick yellow outline, emulating the titular text of 'STAR

WARS', replacing it with a verbi-visual representation of the accompanying soundtrack which begins with a instantaneous 'explosion' of sound. The first 'stanza' of text begins to emerge in its wake, again shrinking into the distance, and again describing the moment of the big bang by describing the impact of that burst of sound at the outset of Williams' theme, highlighting its marking of the difference between a moment of nothingness (silence) and everything (the universe/sound) in which the music fills the conceptual space-time of the score-in-performance. All of this takes place within that initial moment that we call the big bang, and within, therefore, that sudden burst marking the beginning of Williams' piece.

The second section deals with the next phase of the 'big bang', known as 'inflation'. Inflation was proposed in 1980 by physicist Alan Guth which claimed that, in its very early stages, the universe underwent a period of hyperexpansion – inflating rapidly in size before slowing down to a constant rate of growth. As Michio Kaku explains:

> [Guth] reasoned that our visible universe was probably a tiny patch in the original fireball. The patch itself was uniform in density and temperature. But inflation suddenly expanded this tiny patch of uniform matter by a factor of 10^{50}, much faster than the speed of light, so that the visible universe today is remarkably uniform.[170]

The piece equates this with the second stage of Williams' piece, which makes a brief connection between the initial explosion of sound and the rest of the piece, a simple bar of four notes that emerge in rapid succession, leading into the near uniform melody of the rest of the piece. Following the sudden introduction, and

[170] Michio Kaku, *Parallel Worlds*, p.89.

this brief section of rapid successive beats settles into a cyclical and consistent rhythm bringing with it the music of *Star Wars* at its most iconic. In describing this, the text on the screen is initially much larger than that of the previous section, appearing tightly compressed and it seems to shrink at a much faster rate, giving the impression of something inflating rapidly. Following this, the text marks the slowing down of inflation into the gradual and constant growth of the universe by emerging on screen with a significantly reduced distinction between the size at which it appears initially and the rate at which it shrinks into the distance. Within this, the third phase equates the uniformity of this section of the melody of Williams' theme – the coalescing of the individual notes into the rhythm which makes up the main body of the piece – with the cooling of energy into matter, and the coalescing of matter, over time, into planets, stars, and galaxies.

Poems 30a and 30b – 'Superforce' - explore the emergence of the four fundamental forces from the big bang. It is generally accepted that, in the very early universe the four forces were, in fact, part of a single 'superforce'. The 'cooling' of the immense temperatures caused by the 'big bang' caused each of these four fundamental forces to 'break away' from one another. Through the work of Sheldon Glashow, Abdus Salam, and Steven Weinberg, a quantum field theory of the weak nuclear force was developed, known as *quantum electroweak* theory. As Brian Greene describes:

> At high enough energy and temperature – such as occurred a mere fraction of a second after the big bang – electromagnetic and weak force fields *dissolve* into one another, take on indistinguishable characteristics, and are more accurately called *electroweak* fields. When the temperature

> drops, as it has done steadily since the big bang, the electromagnetic and weak forces *crystallize* out in a different manner from their common high-temperature form – through a process known as *symmetry breaking*.[171]

It seemed logical that, if the electromagnetic and weak nuclear forces were united in the early stages of the universe, that the other fundamental forces – the strong nuclear force and gravity – were also united along with them. Symmetry breaking, the process responsible for this splitting of the four fundamental forces. Michio Kaku writes:

> According to this theory, the cooling of the universe after the big bang is analogous to the freezing of water. When water is in liquid form, it is quite uniform and smooth. However, when it freezes, millions of tiny ice crystals form inside. When liquid water is totally frozen, its original uniformity is quite broken, with the ice containing cracks, bubbles, and crystals.[172]

These four forces did not break away from each other all at once. Physicists believe that gravity was the first of the forces to break away 10^{-43} seconds after the big bang (known as the Planck Time), when the universe was about 10^{32}°K.[173][174] At 10^{-35} seconds after the bang, when the universe had cooled to 10^{27}°K the strong nuclear force separated, and then, finally, at 10^{-12} seconds and

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[171] Brian Greene, *The Elegant Universe,* pp.122-3.
[172] Michio Kaku, *Parallel Worlds*, p.84.
[173] The Kelvin scale is a measure of temperature that is almost identical to the Celsius scale, differing in that, while the Celsius scale places its 0° at the freezing point of water, the 0° of the Kelvin scale sits at 'absolute zero', the point at which particles have absolutely no energy, which is roughly -273.15°C.
[174] 10^{-43} seconds = 0.00000000000000000000000000000000000000001 seconds, and 10^{32}°K = 100,000,000,000,000,000,000,000,000,000,000°K.

at 10^{15}°K the electroweak symmetry was broken, and became the electromagnetic and the weak nuclear forces.

Consisting of a 'Side A' and a 'Side B', this piece is an electronic poem that explores the separation of the four fundamental forces. Both 'sides' take the form of Venn diagrams that shift and change as the piece progresses. 'Side A' begins with what seems to be a single circle with a mass of indistinguishable words laid over one another in the center. Part of this circle begins to expand and break away, revealing the word 'Gravity' at its center, growing in size, emphasizing gravity as the largest and the weakest of the four forces. Following this, a second circle begins to break away, this time shrinking, yet, becoming bolder and visually denser, revealing the 'Strong Nuclear Force', contracting to a comparatively smaller circumference. The remaining circle then begins to split into two, both contracting this time, with one becoming bolder – revealing 'Electromagnetism' – and the other becomes fainter, revealing the words 'Weak Nuclear', leading to the concluding line of the piece; 'You are here / 13.7 billion years later.' Alongside all of the phase transitions of the piece text appears on the screen that describes the freezing of water, from a state of liquidity and uniformity, to the formation of crystals, breaking its symmetry.

'Side B', on the other hand, initially displays a similar circle at the center of which is the word; 'Water'. The four circles begin to separate at the same time, in a similar way to 'Side A', as the temperature drops, eventually transforming the circles into hexagons, and the word at the center of each from 'Water' to 'Ice', visualizing the formation of ice crystals. The text that accompanies this 'side', contrasting with that of 'Side A', consists of a combination of quotes from *The Elegant Universe* concerning symmetry breaking in the early universe.

Both sides take their cue from Christian Bök's poem 'Crystals', in which Bök describes a different kind of symmetry breaking – crystallization – by juxtaposing similar kinds of comparisons.[175] Within each side there is symmetry between the visualization and the subject of the text by the relationship of analogy. Between the two sides, there exists a similar symmetry of form. These two instances of symmetry form a feedback loop between the analogy and the physics, not only within each 'side' but also between them, in which the physics is translated into the analogy, and the analogy is then re-translated back into the physics.

Poem 31, 'Afterimage,' introduces the Cosmic Microwave Background Radiation. In the 13.7 billion years since the 'big bang', the electromagnetic radiation released has been cooling, decreasing in energy from gamma rays through to low energy radio waves permeating the whole universe. Its existence was predicted by physicists George Gamow, Ralph Alpher and Robert Hermann, and was discovered in 1965 –accidentally – by Bell Laboratories employees Arno Penzias and Robert Wilson. Working on an antenna, they were receiving a constant hiss that appeared to be coming from all directions. They eventually they realized this was, in fact, the electromagnetic echo of the dawn of creation Gamow and his team had been searching for. In 2001 NASA launched the Wilkinson Microwave Anisotropy Probe (WMAP), which successfully attempted

[175] Christian Bök, 'Crystals', from *Crystallography*, (Ontario: Coach House Books, 2011), p.12. In Bök's piece, he begins by describing a crystal as an 'atomic tessellation, a tridimensional / jigsaw puzzle in which every piece is the same shape', and then compares this in the third stanza to 'a breeze blowing sand / into the form of a castle, / or a film played backwards / of a window being smashed', concluding the poem with the line 'A word is a bit of crystal in formation.'

to capture an image of this radiation, providing a detailed image of the universe as it was 380,000 years after the 'big bang'.

The interactive e-text *Colour Uncovered* contains an optical illusion entitled 'See Spots Run', originally designed by Jeremy Hinton, also known as 'Lilac Chaser' or the 'Pac Man Illusion'. This consists of a large grey circle in which is embedded a ring of smaller magenta circles. When activated, a sequence begins in which a single magenta circle is removed, following a clockwise path, producing the impression that a green circle has replaced whichever original has been removed, and therefore the illusion that a green circle is moving around the ring. Exploratorium, the team behind the interactive book, write:

> The green dot is an *afterimage* – something you see after your eyes have adapted to looking at something else. After perhaps 10 seconds, the light-sensitive cells in your eyes don't respond very strongly to magenta. When you look at the gap between dots, you see white light minus magenta, which is green.[176]

Following the way Jim Andrews adapted the popular arcade video game *Asteroids* to create his electronic poem 'Arteroids', this piece recreates the 'See Spots Run' illusion on screen to explore the concept of the CMBR as shown in the WMAP image (presented as the poem's epigraph).[177] The language of the poem replaces the 'X' in the centre of the grey circle, at which the reader is instructed to stare, so that they can experience the illusion as well as read the text. The

[176] Exploratorium, 'See Spots Run', *Color Uncovered,* 2011.
[177] Jim Andrews, *Stir Fry Texts*, 1999-2000, http://www.vispo.com/StirFryTexts Andrews' piece uses the same visual style as the game, replacing the ship and the incoming 'asteroids' with words, allowing the reader/user to manipulate a central word (a theme) and fire at incoming words and shatter them into their individual letters.

illusion presents the afterimage created by light-sensitive cells in the human eye, while the text discusses and attributes the same principle to the cosmic background radiation, allowing the reader to experience the cosmic microwave background radiation's presence throughout the universe through its miniaturization into a linguistic construct.

Universal Dynamics (Poems 32-34)

Poem 32, 'Starbeast', uses Ridley Scott's 1979 science fiction horror film *Alien* to explore stellar formation. The piece uses a story from the film's production, concerning the writing of the film –told in numerous interviews by writers Dan O'Bannon and Ronald Shusett – as an analogy of the formation of stars. Describing this process, Stephen Hawking writes:

> A star is formed when a large amount of gas (mostly hydrogen) starts to collapse in on itself due to its gravitational attraction. As it contracts the atoms of the gas collide with each other more and more frequently and at greater and greater speeds – the gas heats up. Eventually, the gas will be so hot that when the hydrogen atoms collide they no longer bounce off each other, but instead coalesce to form helium. The heat released in this reaction, which is like a controlled hydrogen bomb explosion, is what makes the star shine.[178]

The actual process of the collapse of the gaseous cloud also relates to Einstein's theory of relativity, in which the presence of matter creates a gravitational field that increases in proportion to its density.

[178] *A Brief History of Time*, Stephen Hawking, pp.90-1.

'Starbeast' presents itself in three sections. The first of these – 'Cloud' – begins with a cloud of diffuse fragments of words that seem to make little sense. Gradually these fragments begin to coalesce, with words slowly assembling, until they form the outline of a rough circular shape. Here the text describes to the reader the initial stages of O'Bannon and Shusett's process in producing the screenplay for *Alien*.[179] This speaks of the two writers expressing interest in exploring a situation in which the crew of a spaceship is confined on their craft with a hostile lifeform. A

The second section – simply labeled 'Proto' – presents a clearer circle defined by four curving arcs of text, rotating on the screen. At this stage the text takes on the same visual form used in the prologue section of Brian Kim Stefans' 'The Dreamlife of Letters', albeit with greater coherence and specificity of purpose.[180] The text of each 'arm' of this 'proto-idea' identifies four aspects of O'Bannon and Shusett's initial idea for their screenplay; namely, the ship, its small crew, the threat, and the fact that they are confined with the threat on board their vessel. After one full revolution a second set of textual arcs begin to appear one by one, giving the impression of accretion. This creates a sense of an increase in the ideas being 'pulled' into the construction of the narrative of the screenplay, each identifying a specific question concerning the connection of narrative elements. Finally, a third set of 'arms' appear, again one by one, this time presenting the solution to their narrative problems, forming what could become a logical and coherent storyline; the renaming of the film from *Starbeast* to *Alien*, and the decision that the creature would get on board through a

[179] *Alien Evolution* (DVD), 20th Century Fox Home Entertainment Inc., 2001.
[180] Brian Kim Stefans, *The Dreamlife of Letters*, 2000, http://collection.eliterature.org/1/works/stefans_the_dreamlife_of_letters.html

crewmember that had been impregnated with it. The last arm in this set features the quote of Shusett who, in a cinematic 'eureka' moment, had called O'Bannon and announced that the solution would be that "The alien screws one of them."[181] At this point the white text as a whole begins to shrink towards the center of the screen, slowly moving through shades of orange and yellow, until all of the text of which the 'proto-idea' was comprised is compressed into a small area before expanding again, leaving in its wake a yellow circle – the conceptual 'star' of the film - and the words 'Main Feature', mimicking the 'main sequence' of a star whose process of nuclear fusion has just begun.

Poem 33, 'Black Hole', concerns a strange universal phenomenon. In relativity, the degree to which space is warped by the presence of matter is determined by, the density of matter. Great densities of matter, as a consequence of general relativity, produce an extremely strong gravitational field. For collapsing stars with a large enough mass, this density may create a black hole, first discovered by astronomer Karl Schwarzchild. To quote Brian Greene:

> [Schwarzchild] showed that if the mass of a star is concentrated in a small enough spherical region, so that its mass divided by its radius exceeds a particular critical value, the resulting space-time warp is so radical that *anything*, including light, that gets too close to the star will be unable to escape its gravitational grip.[182]

The piece explores the concept of the black hole through a parallel with the act of reading and re-reading a section of text.

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[181] *Alien Evolution* (DVD), 20th Century Fox Home Entertainment Inc., 2001.
[182] Brian Greene, *The Elegant Universe*, p.78-79.

A sequence of six textual visualizations is presented, beginning with a circular 'paragraph' of writing which is also a single sentence. This sentence describes its own reading, commenting on the attraction of the eye to the marks that make themselves distinct against the blank page, and how, in sequence, these marks – letters – coalesce into words, and whose laying out in sequence 'pulls' the reader through the sentence in search of something meaningful. The second image presents the same sentence. This sentence, now having been read, has nothing more to offer to the search for meaning, and as such, as the text beneath states, has 'nothing left to say', nothing to resist the pulling of a reader's attention/focus through a text along the path of words in the search for meaning. The text begins to 'collapse', with the line spaces and the spaces between letter decreasing, shrinking and deforming the circle into an oblate variation of its former self. The text's collapse descends into illegibility, into a smear, and then finally into a dot on the page – a full stop; the final mark of a sentence. The form of the sequence altogether is reminiscent of René Fouconnet's typographical piece 'RF .22 .301. Divertissement mecaongraphique', which features a series of symbols and characters seemingly descending towards a compressing center, which, in this piece is extended into six distinct sections (rather than a single piece).[183] Just as the black hole marks the final stage of a massive star whose mass is compressed into a density so immense that nothing can escape, the full stop marks the final stage of a sentence, the point at which that sentence cannot offer any further meaning.

[183] René Fouconnet, 'RF .22 .301. Divertissement mecaongraphique', from *Typoésie,* p.377.

'Meaning', here, is offered as a supplement to 'light' in the context of a black hole. Just as Derrida's wrote 'there is no outside-text' in *Of Grammatology*, here it could be said that for anything that falls into the black hole, with no chance of escape, that 'there is nothing outside the black hole'.[184] In the poem, within that single sentence, there is no sentence outside of the full stop. At the final stage of the poem, the meaning of the text cannot extend beyond the 'hole' on the page, and the reader, being outside the 'hole' cannot see inside.

Poem 34, 'Holding Together/Pushing Apart' focuses on another universal problem posed by Einstein's theories of relativity. The issue was that the amount of observable matter in the universe would only account for about 4% of its mass, leaving 96% unaccounted for. In the 1930s Swiss astronomer Fritz Zwicky made a strange observation concerning clusters of galaxies. As Brian Green discusses in *The Fabric of the Cosmos*:

> [Zwicky's] analysis showed that many of the fastest-moving galaxies should be flung clear of the cluster, like water droplets thrown off a spinning bicycle tire. And yet none were. Zwicky conjectured that there might be additional matter permeating the cluster that did not give off light but supplied the additional gravitational pull necessary to hold the cluster together.[185]

[184] Jacques Derrida, *Of Grammatology* (trans.)Gayatri Chakravorty Spivak (Baltimore: Johns Hopkins University Press, 1976) p.158. That is, if we interpret 'there is no outside of the text' here to mean that, as modern human beings are capable of only understanding the word through language, then it effectively makes no sense to say that, for us, anything can be said to exist outside of language.

[185] Brian Greene, *The Fabric of the Cosmos*, pp.294-5.

Zwicky referred to this kind of matter as 'dark matter'; matter that does not interact electromagnetically. Dark matter, it has been calculated, would comprise 23% of the mass of the universe, which still leaves a discrepancy of 73%.

Through the 1990s, astronomers at both the Lawrence Berkley National Laboratory and the Australian National University, conducted observations on supernovae in an effort to determine the deceleration of the expansion of the universe. Turning to Brian Greene's commentary, their results came as a complete surprise:

> Ever since the universe was about 7 billion years old, its expansion rate has *not* been decelerating. Instead, the expansion rate has been *speeding up* . . . Ordinary matter and energy give rise to ordinary attractive gravity, which slows spatial expansion. But, as the universe expands and things get increasingly spread out, this cosmic gravitational pull, while still acting to slow the expansion, gets weaker . . . Gravitational repulsion would have been overwhelmed by the usual gravitational attraction of ordinary matter, yielding a net slowing of expansion, in keeping with data. But then, as ordinary matter spread out and its gravitational pull diminished, the repulsive push of the cosmological constant (whose strength does not change as matter spreads out) would have gradually gained the upper hand.[186]

This constant repulsive force became known as 'dark energy'. Further calculations revealed that the amount of dark energy required to cause this kind of accelerated expansion would account for the missing 73% of the mass/energy content of the universe.

[186] Brian Greene, *The Fabric of the Cosmos*, pp.299-300.

The piece is divided into two sections. The former section concerns dark matter, and the second focuses on dark energy, and each using a different item of popular culture. William Shakespeare's *Romeo and Juliet* is used as a means of discussing dark matter, and Nick Cassavetes' 2004 film *The Notebook* is used as a means of discussing dark energy.[187] [188]Both of these source texts share the theme of romance.

The first section – beginning with the heading 'Dark Matter' - introduces the reader to a representation of two opposing curved 'arms' of text – visually recreating the arms of a spiral galaxy – each consisting of a single word: 'Montague' in blue, and 'Capulet' in red. As in 'Starbeast', these arms rotate about a central axis as a series of descriptive text begins to appear progressively in the corner of the screen. This second set of text begins with the first line of the prologue address of *Romeo and Juliet*, highlighting the oppositional nature of the two households within the play, and, by extension, their opposition on the screen as a representation of a galaxy. Two more arms of text appear on the screen – 'Romeo' and 'Juliet' (in their respective 'familial' colours) – while the accompanying text describes the fact that, by right of their family names and the feud between their two 'houses', their familial enmity should cause them to repel one another. Instead, the four arms continue rotating together, while the text, reappearing, goes on to use Romeo and Juliet's 'love' for one another – the narrative element of the play that, rather than the two characters intrinsically hating each other, causes them (and therefore their two families) to be 'bound' together – as a humanized substitute for dark matter.

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[187] William Shakespeare, *Romeo and Juliet*, (London: Penguin Books, 2005).
[188] Nick Cassavetes (dir.) *The Notebook* (USA: Avery Pix, 2004).

The second half of the piece, focusing on dark energy, uses the central aspect of the film *The Notebook*, in which an elderly husband attempts to keep his romance with his wife alive after she deteriorates through Alzheimer's. This section begins by displaying the two central characters' names – Noah and Allie– presented in a circular fashion. These represent two galaxies, while the accompanying text describes Noah and Allie's romance in much the same way as Romeo and Juliet's in the previous section. By right – their chance meeting and genuine affection for one another – they should be held together (by the same force that bound Romeo and Juliet), however, as the piece points out at the beginning of the section 'What good is love without its own memory?' Focusing on this, the accompanying text presents the deterioration of love spatially as a growing distance between them. On the screen, the two representative galaxies slowly drift apart, the void between them becoming larger as the poem progresses until neither is visible, the growing void caused by the fading of memory-function becoming a humanized analogy for the effects of dark energy between galaxies.

Towards a Theory of Everything (Poems 35-37)

Poem 35 – 'Mr. Higgs Takes a Run in the Ocean' – introduces the Higgs field. The quest for the Higgs boson began with a simple question relating to the mass of particles; why do they have the masses they do. As there is an equivalency between mass and energy, then what distinguishes the energy of which an electron is comprised from the energy of a photon? In his book *Massive: The Hunt*

for the God Particle, Ian Sample describes a solution to this, proposed in 1964 by Scottish physicist Peter Higgs:

> Peter Higgs conceived of an invisible field that reaches into every corner of the cosmos. At the beginning of time the field lay dormant, but, as the newborn universe expanded and cooled, it came to life and made its presence known. In that moment the building blocks of matter flipped from being weightless to weighty. [189]

Brian Greene explains this using an excellent analogy:

> To accelerate a Ping-Pong ball submerged in molasses, you'd have to push it *much* harder than when playing with it on your basement table . . . If a particle moves smoothly through the Higgs ocean with little or no interaction, there will be little or no drag and the particle will have little or no mass. The photon is a good example. Photons pass completely unhindered through the Higgs ocean and so have no mass at all. If, to the contrary, a particle interacts significantly with the Higgs ocean, it will have a higher mass.[190]

The Higgs boson mediates the interactions between the Higgs field and the other particles attempting to accelerate through it, resulting in the manifestation of *mass*.

This piece takes the form of a series of parallel horizontal lines that extend from the top of the page to the bottom modifying Greene's 'molasses metaphor', replacing the basement table and the molasses with the scene of a beach sloping gradually into the waters of an ocean. The beach and the ocean are

[189] Ian Sample, *Massive: The Hunt for the God Particle* (Chatham: Virgin Books, 2010) *p.x*.
[190] Brian Greene, *The Fabric of the Cosmos*, p.262.

marked by the use of colour, and the height/depth of either section is mirrored in the intensity of the colour; the beach lines become fainter as they meet the lines of the ocean, giving the impression of one descending into the other, taking inspiration from the visual poem 'Acqua' by Carlo Belloli, in which the page is likewise divided into two sections that simulate two bodies of water clashing.[191] From the bottom of the page the word 'Running' appears repeatedly, positioned in the patterns of footsteps moving from the beach into the ocean, making use of the direction of reading to clarify the direction in which the text moves. Along the beach section the text of the word remains unchanged, yet as it begins to enter the ocean lines the text increases in density as it moves through the water, appearing with greater 'mass' on the page.

The 'beach section' represents a space in which there is no Higgs field, through which someone may run unhindered, and the 'ocean' section becomes a conceptual Higgs field, with the 'footsteps' acting as particles moving from into the Higgs field. The deeper a particle is, the more it is interacting, and therefore the more 'mass' is given to the text. As the implied legs/feet move into the ocean, only then, gradually, as depth increases and, therefore, the interaction with the water, does the difficulty – the *inertia* – begin to be felt.[192]

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[191] Carlo Belloli, 'Acqua', from *Typoésie*, p.242. In Belloli's piece the page is filled with repetitions of the word 'acqua' ('water' in Italian), which are bold in the top half, but not at the bottom. The mid-section of the poem, where the two 'bodies of water' meet is filled with a mixture of bold and non-bold words that describe various properties of water, simulating the 'foam' caused in such a collision.

[192] On July 4th 2012 a particle corresponding to the predictions Peter Higgs made in 1964 was observed, and it was announced that the Higgs boson had, after nearly half a century, been discovered, with Peter Higgs and François Englert being awarded the 2014 Nobel Prize in Physics.

Poems 36a and 36b – 'String Theory' – is the first of two poems based on theoretical propositions in physics, which are, so far, unconfirmed by experimental evidence. String theory's proposition was unlike any other scientific breakthrough in that it was stumbled upon quite by accident. In *Parallel Worlds* Michio Kaku traces its origins to CERN in Geneva, 1968:

> Gabriele Veneziano and Mahiko Suzuki, were independently flipping through a math book and stumbled across the Euler Beta function, an obscure eighteenth-century mathematical expression discovered by Leonard Euler, which strangely seemed to describe the subatomic world. They were astonished that this abstract mathematical formula seemed to describe the collision of two π meson particles at enormous energies . . . Usually, when someone proposes a new theory (such as quarks), physicists try to tinker with the theory, changing simple parameters (like the particles' masses or coupling strengths). But the Veneziano model was so finely crafted that even the slightest disturbance in its basic symmetries ruined the entire formula . . . Eventually, physicists learned that the theory had no adjustable parameters whatsoever.[193]

This would, eventually, become string theory. The theory consists of two caveats: firstly, that all fundamental particles in the universe are, in fact, vibrating strings of energy. Michio Kaku and Jennifer Thompson write in *Beyond Einstein*:

> The superstring theory . . . assumes that the ultimate building blocks of nature consist of tiny vibrating strings. If correct, this means that the protons and neutrons in all matter, everything from our bodies to the farthest star, are ultimately made up of strings. Nobody has seen these

[193] Michio Kaku, *Parallel Worlds*, p.188.

> strings because they are much too small to be observed. (They are about *100 billion billion* times smaller than a proton.) [194]

The second strange feature of the theory is that it requires the existence of ten dimensions – nine spatial dimensions, and one of time. Higher dimensions of space are not a new idea, and, in fact, theoretically date back to 1919, shortly after Einstein had published his work on general relativity. A physicist named Theodor Kaluza speculated on the possibility of a higher dimension of space existing and that by adding a fourth spatial dimension the equations of general relativity simplified into none other than James Clerk Maxwell's equations of electromagnetism. In 1926 a second physicist – Oskar Klein – provided a theoretical framework that showed it was possible for this fourth dimension to be 'curled up' at every point in space in such a way that it would not be experienced in the macrocosmic world, but would have indirect effects, namely by affecting the particles that were small enough to pass through it. Over the years this theory – named Kaluza-Klein theory – became modified, and found its home, inevitably, in string theory.

The poem itself, using acetate sheets, is presented in two parts. 'Side A' consists of a textual 'ball' to be read from the outside inwards. This spiralling form of text takes inspiration from Tom Ockerse's visual poem 'La roué des chiffres', which features a spiralling series of written forms of numbers of various civilisations.[195] The text conceptually asks the reader to imagine

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[194] Michio Kaku and Jennifer Thompson, *Beyond Einstein* (Oxford: Oxford University Press, 1999) pp.4-5.

[195] Tom Ockerse, 'La roué des chiffres', from *Typoésie,* pp.326-7. From the outermost point of the spiral, Ockerse's piece moves from modern popular/commercial typographical numerical figures through the figures of various mathematically successful civilisations, such as Hindu/Arabic numerals,

themselves with the abilities of the DC Comics superhero The Atom, a.k.a. Ray Palmer, who is able to shrink himself down to subatomic sizes, drawing on an element of popular culture as a conceptual vehicle for the reader to traverse the piece.[196] As layers are peeled away, the outer lines of the text fade away, until the 'ball' becomes a dark circle of inner text and outer text, separated by an inner boundary of grey text; an atom (with its nucleus at the centre and its electron orbit). Peeling away more layers, the inner text becomes completely grey (indicating, now, just the electron), and, ultimately this text fades as well, leaving a single line of text at the final layer; a circular line with an overlaid 'vibrating' effect' that reads 'like an infinitely thin rubber band each particle contains a vibrating oscillating dancing filament that physicists have named a string', a line taken from Brian Greene's *The Elegant Universe*.[197] 'Side B' presents a similar concept, this time using a 'ray' of light moving from one side of the page to the other. The text itself remains much the same, making adjustments to reflect a beam of electromagnetic radiation rather than a concrete object. The reader encounters first a single point-like photon, which then fades into a single line of text – a string – consisting of the same text as 'Side A', again in ten dimensions. The difference between the two sides is that 'Side A' refers to matter particles – through the electron – which are generally thought to exist as 'closed loops'

Roman numerals, Chinese figures, Egyptian hieroglyphics, and Babylonian cuneiform, with the center being a human hand. This hand can be said to represent humanity's most fundamental form of mathematics in this piece, and it is this idea of 'spiralling' to that most fundamental part that the poem 'String Theory' makes use of.

[196] 'The Atom' and 'Ray Palmer' were created for DC Comics by Julius Schwartz, Gardner Fox, and Gil Kane, in 1961.

[197] Brian Greene, *The Elegant Universe*, p.14.

(hence the circular shape), whereas the string of 'Side B' is an 'open string', accounting for force particles.

Poems 37a and 37b – 'M-Theory' – continue the theme of extra spatial dimensions with an exploration of the contemporary extension of string theory, known as M-theory. This theory emerged from a problem string theorists encountered in the 1980s. By that time not one, but *five* different string theories were proposed. While all five shared the basic aspects of the theory, they differed from one another in individual properties: for example, exactly *how* the extra dimensions were curled up. This problem was the result of the fact that, as physicists realized, string theory was far from complete, and that it was only an approximation. Its accidental discovery had meant that physicists were forced to break from traditional scientific progression and attempt to retro-engineer a theory, and the theory itself may just have been far in advance of what physics at the time was prepared for.

M-Theory proposed a framework that incorporated all five string theories in a novel way. In *The Elegant Universe* Brian Greene writes:

> We see that the five new string theories were thought of as being completely separate. But, with the newfound insights emerging from recent research . . . we see that, like the starfish's five arms, all of the string theories are now viewed as a single, all-encompassing framework . . . This overarching framework has been provisionally called M-Theory.[198]

M-theory it expands on string theory in two distinct ways. The first of these is that, recalling that string theory is viewed as an *approximation* of a final theory,

[198] Brian Greene, *The Elegant Universe*, p.286.

so too were the number of extra dimensions; M-theory in total posits eleven dimensions (ten spatial, one temporal) rather than ten. The second, and most significant in relation to this piece, is that it does not include only strings, but a whole host of other objects known as 'membranes' (or, often, just 'branes' for short) - hence the 'M' of M-theory. Michio Kaku explains the role of these membranes in M-theory:

> In this picture, point particles are called "zero-branes," because they are infinitely small and have no dimension. A string is then a "one brane," because it is a one-dimensional object defined by its length. A membrane is a "two-brane," like the surface of a basketball, defined by length and width. (A basketball can float in three dimensions, but its surface is only two-dimensional.) Our universe might be some kind of "three brane," a three-dimensional object that has length, width, and breadth. [199]

Brian Greene expands slightly on the significance of this variety of branes in *The Fabric of Reality*:

> A three-brane has three dimensions, so if it were large – perhaps infinitely large – it would *fill* all three big spatial dimensions. Whereas a one-brane and a two-brane . . . are objects that exist *within* our three large space dimensions, a large three-brane would occupy all the space of which we're aware. This raises an intriguing possibility. Might we, right now, be living within a three-brane?[200]

Our universe would be one of many *p*-branes floating *within* dimensions far *beyond* our own comprehension.

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[199] Michio Kaku, *Parallel Worlds*, p.214.
[200] Brian Greene, *The Fabric of Reality*, pp.387-8

The piece itself takes the form of an interactive electronic graphemechanical poem, divided into two parts. The two 'sides' of the piece explore the concept of 'branes' from both a linguistic and a physical perspective. 'Side A' posits the possibility of a brane perspective applied to language itself, writing in particular. Each of the *p*-branes is assigned a symmetrical grapehemechanical concept in language. The reader encounters these at three stages in the piece – 'Brane-y grapheme', 'Brane-y writing', Brane-y language', and 'Membranous language'. At each of these title screens a selection of symbols is displayed below the title according to the equivalence of the *p*-brane and the linguistic element. The reader clicks on these symbols and is taken to a connected display consisting of a series of poems within the overall poem, of which the overall poem is constructed. These poems use written language as a means of exploring the 'branes' of M-theory in a similar fashion to Veronica Forrest-Thomson's exploration of hyphens in her poem 'The Hyphen', which gives the conceptual hyphen an imagined voice with which to describe its function, versatility, and pervasiveness.[201] The first of these – 'Brane-y grapheme' – proposes that punctuation marks can be considered to be the zero-branes of language, in that, just as a point-like particle itself has zero dimensions, so the punctuation mark, saying nothing in itself, but, rather, directly effecting the 'flow' of written language. The structure of this poem takes the form of two slanted stanzas of text that resemble commas, taking the form of its subject. The

[201] Veronica Forrest-Thomson, 'The Hyphen', from *Collected Poems*, p.88. Thomson's poem, like the poetic sections here and in Side B, follow both Lucretius' and Hugh MacDiarmid's preference for simple statements, unadorned by elaboration, allowing the concept to speak through and express its own fascination and beauty through its own explanation and the reader's understanding thereof.

second – 'Brane-y writing' – presents the letters/characters of a language as the one-branes, or the 'strings' of language. The interactions of letters give rise to the patterns of reading, which, in writing, follows a linear path – length – constituting a singular spatial dimension. The third section 'Brane-y language' describes the linguistic 2-brane as the page itself, a space on which writing occurs with both length and breadth, being read in two directions (in English, left to right, top to bottom). To emphasize this, the poem here is structured simply as a prose poem, filling the center of the screen as a plain block of text, demonstrating the way in which the page itself provides two dimensions for writing. The final section – 'Membranous language' – emphasizes the 'M' of M-theory, and, following the propositions discussed in relation to the poem 'String Theory', posits that the idea of the book as a physical object would, linguistically, constitute anything above the 2-brane (the page) being, as it is, the sum of its pages. As a visual reflection of this, this piece takes the form of a prose poem in three columns, with each column representative of a single page. 'Side A' concludes by drawing the concept of physics and language together by describing the multiverse itself as being a book consisting of eleven pages, of which our universe would be considered to be a chapter of three – a three-brane – ending the 'side' with the famous words of Derrida; '*il n'y a pas de hors-texte* (there is nothing outside of the text)'.[202]

'Side B' follows a similar format, though this time concerning itself explicitly with the concept of branes in M-theory. The three 'levels' of this poem – 'Brane-y world', 'Brane'y cosmos', and 'Membranous multiverse' – discuss the problems arising in string theory, leading up to the formulation of M-theory and

[202] Jacques Derrida, *Of Grammatology*, p.158.

the postulation of the existence of branes. The forms of each of the poems in this piece specifically reflect the shift from string theory to M-theory, beginning with the zero-brane ('Brane-y world') in which the text is structured as a downward pointing triangle leading to a full stop – a single point or zero-brane – while the text discusses the state of affairs of string theory between the 1980s and 1990s, introducing the concept of branes, the point-like particle being the most basic form. 'Brane-y cosmos' introduces the strings of string theory within the context of M-theory – as one-branes – drawing on Euclid's description of a line (as the distance between two points). This section takes the form of a textual star, using an image presented by Brian Greene in *The Elegant Universe*, in which the five theories of string theory are seen as the five protruding peaks of a star shaped mountain (M-theory); only one can be seen at a time from the ground, and only when viewed from above can the full range be observed.[203] The final section – 'Membranous multiverse' – presents the possibility that our own universe may just be a 3-brane existing in the higher dimensions of M-theory, emphasizing how other branes – such as strings – exist within. The text here is structured strangely, as two conjoined parallelogram stanzas that give the impression of a text with length, breadth, and depth, being read through, down, and along – three dimensions. This 'side' of the piece concludes by mirroring 'Side A', describing the universe as a three-brane floating in eleven dimensional space. The final slide of the piece displays the words "My God! it's full of stars!" taken from Arthur C. Clarke's novel *2001: A Space Odyssey*.[204] In this, near the end, astronaut David Bowman, upon entering one of the infamous monoliths, gives these as his last

[203] Brian Greene, *The Elegant Universe*, pp.286-7.
[204] Arthur C. Clarke, *2001: A Space Odyssey* (Chatham: Orbit Books, 2008) p.216.

recorded words as he observes that the monolith acts as a gateway to another part of the universe. Here, the quote is appropriated, giving this feature of the monolith to the universe itself which, when viewed as a three-brane, is literally a cosmic entity that is full of stars.

Beyond the Universe (Poems 38-39)

Poem 38, 'Linguistic Multiverse', focuses on what is known as the 'multiverse theory of reality'. This is the idea that our universe exists amid a multitude of other universes, referred to as the multiverse. As Brian Greene explains:

> Imagine that what we call *the* universe is actually one tiny part of a vastly larger cosmological expanse, one of an enormous number of island universes scattered across a grand cosmological archipelago . . . [Andre Linde] has found that the brief but crucial burst of inflationary expansion discussed earlier may not be a unique, one-time event. Instead, he argues, the conditions for inflationary expansion may happen repeatedly in isolated regions peppered throughout the cosmos, which then undergo their own inflationary ballooning in size, evolving into new, separate universes.[205]

The multiverse theory in itself has also become a staple of popular culture within science fiction television series and films, and as such the cinema/television screen itself can also be said to be multiversal, being a composite of billions of pixels or streams of light (in the case of the projector) in order to create the moving image in its entirety. This piece uses the 'screen' as a vehicle to explore the idea of a multiverse in greater detail.

[205] Brian Green, *The Elegant Universe*, p.366.

'Linguistic Multiverse' presents a patchwork of square blocks of text, each in a different language, and each in a different font. These blocks – patched together like pixels – are all translations of the same text, which is presented in English at the center. The text itself openly describes a universe in the way one might describe a film: as a composition of networked elements (pixels), as something that adheres to laws of narrative, and as a place in which interactions (collisions) produce/create consequential reactions. Throughout this, individual letters are highlighted in red, spelling the phrase 'You are here,' situating the English reader in this particular position. Each one of these blocks represents an individual universe, using the existence of humans of one particular linguistic heritage living in a 'sea' of other languages as its expression of multiversality. Here, the piece uses the multitude of languages on Earth as a means of allowing a conceptual understanding and appreciation of the multitude of universes. Continuing with Brian Greene's description:

> We can imagine that physics varies from one universe to another. In some, the differences may be subtle: For example, the electron mass or the strength of the strong force might be a thousandth of a percent larger than in our universe. In others, physics may differ in more pronounced ways: The up-quark might weigh ten times what it weighs in our universe, or the strength of the electromagnetic force might be ten times the value we measure . . . And in other universes, physics may differ in still more dramatic ways: The list of elementary particles and forces may be completely distinct from ours.[206]

Each of the different languages, while patched together on the same 'screen' and conveying (roughly, owing to the flaws of translation), obeys its own 'laws of

[206] Brian Greene, *The Elegant Universe*, p.367.

language', just as each universe obeys its own laws of physics. Some of these may seem, in parts, subtly similar to the English 'universe' - some words in the French or German or Spanish translations may be recognizable to the English reader. In others, though words may not be recognizable to the same reader, the characters remain familiar. In others, particularly those at the outer edges, the very characters used are vastly different. Where Tom Ockerse, in 'La roué des chiffres', juxtaposes sequences of culturally different numerical characters in historical sequcences, these blocks occupy no particular place in no particular order, coexisting simultaneously.[207] Together, they create a multiverse of languages that embody the varying categories of parallel universes described by Greene: universes as extensions of our own, universes that exist alongside and emerging from our own, and universes that are removed and separate from our own.

Poem 39 – 'Art/Science' – concludes the section by reflecting on the relationship between science and poetry as they are treated throughout this thesis. It seems that much of the work in science and poetry have been concerned with the appropriation of science as metaphor, in which scientific references appeared as little more than useful tools of expression, form, and narrative, or in which the 'poetic' is used to refer not to poetry, but to a kind of intellectual deficiency (discussed in Chapter One). This is evident in many of the pieces exhibited by the University of Liverpool's 'Poetry and Science Hub', such as Tim Kendall's 'Euridice', Roald Huffman's 'Monolayer', and 'Marco Petrucci's

[207] Tom Ockerse, 'La roué des chiffres', from *Typoésie,* pp.326-7.

'Plutonium'.[208] Each of these poems use physical references: e.g. 'Euridice' refers to Einstein's theory of special relativity as a reflection of two lovers spending time together, which seems to concentrate too much on Einstein's rather whimsical depiction of his theory - 'when a man sits with a pretty girl for an hour, it seems like a minute, but let him sit on a hot stove for a minute – it's longer than an hour; that's relativity!' However, the actual physics does not emerge. This thesis, taking the opposite approach, making physical theories the explicit subject of its poems and using various analogies, metaphors, and articles of popular culture for the expression of those theories, has demonstrated a model of science poetry that, like Lucretius and Hugh MacDiarmid, does not diminish science, but celebrates it. As a result, the closing of the perceived gap between 'art' and 'science' seemed to be an appropriate focus for the concluding poem 'Art/Science'.

Considering what were perceived to be fundamental characteristics of art and science in relation to each other, one of the most universally accepted aspects of art was imagination, or more precisely the 'imagination of possibilities'. Science, on the other hand, concerns itself with defining reality. Between the two lies a conflict in general perception: if art concerns imagining what 'could be', then science, by defining what 'is', seems to nullify what has been imagined. The piece conceptualizes this conflict in terms of exploration; art is concerned with imagining what strange lands might lie beyond our borders, and science is concerned with going beyond those borders and finding out what

[208] University of Liverpool, 'Poetry and Science Hub', https://www.liverpool.ac.uk/poetry-and-science/poems/

exactly is out there. This paradigm of the gap between science and art – the borderlands paradigm – formed the basis of the poem.

'Art/Science', using the metaphor of exploration mentioned above, presents two incomplete poems on acetate, each discussing one perspective of the paradigm: one side focusing on art as an imaginative discipline, and the other on science as a defining discipline. The two poems manifest their incompletion through gaps within the text. When the two poems are combined – through folding – it is revealed that the gaps in one poem are filled by the text of the other, and vice versa, so that the complete text could only be accessed as a combination of both. What is lacking in either discipline can be found in the other, and also that in order to appreciate our place in the universe we must understand the universe itself, and, conversely, we can only understand the universe itself when we appreciate our place within it, not only demonstrating the unity of 'art' and 'science', but also emphasizing its importance.

Differant, not Different

Writing on the significance of Newton's second law of motion (force = mass x acceleration), Robert Crease writes that:

> Where *F = ma* appears . . . we see the heavens and the earth as the same place . . . [Newton's strange new world was found in our world – but it is not our world, either, nor one we could live in. We humans, even the scientists among us, inhabit what philosophers call the 'lived world', amid designs, desires, and purposes: we live in an Aristotelian world. The world Newton discovered is an abstract one that appears by changing what we look at and how we look at it . . . The equation . . . is the 'soul' of

> that world, as Wilczek wrote, serving to define its structure, and part and parcel of every event that takes place in it.[209]

One of the objectives of the poems of this thesis was to take the physical universe and express it in the human terms of the 'Aristotlean' world, to express the universe, calling for a common ground between the universal and the everyday, inviting the reader to reconsider their thinking regarding a) how to view the universe, and b) how to view the 'Aristotlean' world around us, and in both to ask different questions upon encountering the similarities/differences between the two.

Throughout this collection a number of patterns have been seen to exist simultaneously in both physics and in language that are remarkably similar. The widely held notion that the arts and the sciences should be kept apart is born of misunderstanding and ideological relics of a time when interdisciplinarity was not prevalent. Science, largely thought to be overly rigid and prescriptive, through quantum mechanics, has revealed that structural frameworks and fluid ideas are not diametrically opposed, but, rather, like Derrida's critique of western metaphysical binary values, exist in harmony with one another, and a mathematical model has been produced – complete with theoretical structures – that maps something as strange, fluid, and seemingly unstructured as the mysterious sub-atomic realm, a place dominated by probability and what seems to us to be paradox. Similarly, the arts and sciences are, rather, relatively *differant* rather than being incompatibly different. Language itself behaves in paradoxical ways, and relies on the interpretation of the reader in order for

[209] Robert P. Crease, *The Great Equations*, (New York: W. W. Norton, 2009) pp. 63-4.

meaning to be produced, and yet it functions as a structure of meaning, as a machine capable of producing a variety of probable meanings. Just as an electron seems to be both a wave and a particle, so too does language seem to be neither wholly a set of components, nor wholly their sum, but something that exists between the two. This is never more evident than when viewed as writing, as graphemechanical structures serve to emphasize on the page, the way in which language behaves, being simultaneously demonstrative and descriptive. Language itself is our means of communicating with and comprehending the world around us, and in physics this language takes the form of complex mathematics with which physicists are able to define the laws of nature themselves, to identify exactly how the world works and why.

At the end of the day, science and literature are different disciplines, and as such they do require different approaches: scientific models are required to conform to experimental observation and to be able to make predictions concerning related phenomena, in which multiple possible models cannot all be said to be simultaneously (the universe obeys the same single set of laws at each and every point), whereas in literature – poetry in particular – multiple possible interpretations can be said to be valid simultaneously, provided they are based on evidence found within a text. When one approach or discipline is forced on the other, much of the other will be lost, and this approach itself is dominating, artificial and contrived, rather than organic and interdisciplinary. Science imposed on literature damages the range of literary possibilities, limiting expression, whereas literature imposed on science would result in a loss of objectivity, reliability, and diminishes our understanding of the universe around us. To see this we only need to refer back to the attitudes of the Royal Society

(namely that the goal of science was to dominate and control nature), and the reactions of several of the Romantic poets (such as Keats' and Worsworth's belief that science drained the world of its sense of wonder), both discussed in Chapter One Only when two disciplines are approached as equals – as *differants* – can anything positive emerge while losing as little of either as possible. This has been the approach of this whole collection. Rather than view science through the lens of literature, or vice versa, a series of translations and dialogues between the two have occurred, through which the differences and the similarities can be identified and appreciated, and the similarities in particular can begin to create a feedback loop through which a scientific perspective can open possibilities for exploration in literature – not just in terms of subject matter, but also in revealing alternative perspectives on literature – and the literary perspective can offer new and interesting vehicles for exploring and appreciating scientific discoveries.

Poetry has a long history of exploring the beauty and mystery of the world, be it in objects, images, concepts, or emotions. By approaching science through the medium of poetry, writers enable themselves to explore the greatest mysteries and the greatest beauties of the universe, seeking, (in the words of Lucretius) to 'break apart the bolts of nature's gates'. In doing so, poets have the potential to explore those fundamental laws of nature from which *everything* humans have ever seen, or done, or felt, has emerged. Poetry itself emerged from those very laws, from 13.7 billion years of dimensional cooling, symmetry breaking of forces, of subatomic interactions, of atomic interactions, of matter formation, of gravity, of coalescence, of star and planet and galaxy formation, of chemical interactions, of millions and millions of years of evolution until a

sentient being is able to use language, is able to examine the structures behind the world, and is capable (metaphorically) of producing a poem; this all comes as a direct result of physical law. If, as Niels Bohr said, 'when it comes to atoms language can be used only as in poetry', then it must also be added that when it comes to poetry, there can be no subject more fundamental, pervasive, and grand in scale than the laws of physics that permit us to write it.

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